THE ORIGINS OF HUMAN FACE RECOGNITION BY YOUNG INFANTS

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DEDICATION

To my family, especially my parents.

To Sarah, my daugther.

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Abstract

The research described in this thesis investigated how newborn babies process information about faces. To answer this question the ability of neonates to discriminate between the face of their mother and that of a strange adult female and to show face recognition was explored.

Existing research on face perception suggested different ages at which face discrimination is possible. Since these studies were flawed in their experimental procedures and stimuli, the validity of their findings could have been questioned.

In an initial experiment, neonates aged beteen 12 and 108 hours (Mean age 51.29 hrs) demonstrated a preference for their mother's face even when auditory cues were unavailable. Since olfactory information was not controlled, the results of very early visual face recognition were inconclusive.

Subsequent experiments were designed to investigate the role of olfactory information in early face discrimination, and to control both olfactory and visual cues independently. Neonates proved to be unable to

demonstrate an orientation preference for the mother based on olfactory information alone, but could demonstrate such a preference when olfactory information was prevented and visual information was available.

Preference for the mother was obtained both when faces varied non-systematically across subjects in terms of facial brightness, and when faces were matched as closely as possible for hair colour, hair length and facial brightness.

The finding of very early face recognition raised doubts about the validity of the assumptions of the two-visual system model, suggesting that only sub-cortical processing is possible in young infants. The proposition of a distinction between cortically and sub-cortically mediated processes needs to be revised.

The second part of the thesis examined the processing of invariant information in young infants. The data of a set of experiments indicated that the ability to detect invariance is absent in the neonatal period, but develops over the first few months. It is partly present at 1 month and continues to develp over the third month. The establishment of an internal representation of the mother's face which includes the different poses and the existence of a better developed storage and retrieval mechanism by the third month is suggested.

Finally, a study which monitored the amount of contact between mother and neonate was carried out and the results indicated that approximately 27% of awake time is spent in face-to-face interaction with the mother over the first three days of life. The finding of a very early recognition of the mother's face despite the neonate not being continually in face-to-face interaction with the mother, suggests that the newborn infant is able to process and store at least some visual information about the mother's face for later use after limited exposure. Such capacity seems to be present in the first few hours of the infant's birth. What visual information is processed and used by neonates is still not known. It is, however, likely that the information does not come from dynamic properties of the stimulus face, but from relatively static information.

Chapter 1

INTRODUCTION TO THE ORIGINS OF HUMAN FACE RECOGNITION BY YOUNG INFANTS

The research described in this thesis is concerned with the ontogeny of face discrimination and especially recognition of the mother's face. The process by which young infants recognize their mother's face must obviously be a complex one involving many constituent processes from the basic perception and recognition of features and characteristics to high level cognitive processes such as the interpretation and storage of information. The complexity of this process is reflected in the difficulties in determining what is being used in the discrimination process. No simple piece of research can examine all the relevant aspects of such a diverse topic, and the investigation of face recognition in young infants described in this thesis therefore focuses on only limited aspects of the problem area.

The main aim of this thesis is to examine the neonate's ability to visually recognize the mother's face in the absence of olfactory information. It is considered intuitively reasonable that when presented with the mother's silent face, a young infant can utilise visual and olfactory information. In the absence of one of these information sources the infant may use the other.

The present chapter is devoted to describing attempts by developmental psychologists to determine infants' looking preferences for different faces which may help in understanding some of the processes underlying face discrimination. This chapter covers the issue which has been the focus of most research: the earliest age at which infants prefer their mother's face to a stranger's.

Evidence from the more formal, experimental studies initially appears to be contradictory to each other. Several studies can be quoted which appear to support the view that maternal face discrimination is not possible before 4 months of age. On the other hand, many studies seem to justify the opposite conclusion and to suggest the possibility that newborns discriminate between their mother and at least a female stranger soon after birth.

Much of the confusion that exists in this area may be due to the fact that results which initially appear to be in conflict turn out, on closer examination, not to be. The problem is one of comparability between methods in that the various results have been arrived at on the basis of totally different procedures.

To provide a framework within which to consider young infants' perception of faces, evidence concerning the basic known visual capabilities of the neonate is initially reviewed, followed by an examination of the two-visual system model.

Since infant visual perception involves both discrimination and memory it was considered necessary to briefly discuss visual memory in the neonatal period. Sex differences in early face discrimination are reported in a separate section toward the end of the chapter. The final section discusses methodological issues.

Thus the present chapter is concerned only with the visual information. Evidence suggesting the young infants ability to detect invariance is reviewed in chapter 5, while studies on the neonates' capacity to discriminate olfactory information are discussed in chapter 3. Auditory cues are not covered in the present research.

1.1 Visual acuity and contrast sensitivity of the neonate

To understand the visual capabilities of newborn infants one must have some measure of the pattern information that they can extract. The general measure is visual acuity. Generally, visual acuity is the ability to resolve detail in a visual target. Psychophysicists define it as the highest spatial frequency an observer can detect (Westheimer, 1972).

In infant research, acuity has often been tested as the discrimination of a fine black and white stripe pattern (grating) from a uniform field of the same average luminance. The pattern information available in vision is not totally characterised by knowing whether young infants can detect the finest detail. Recent work on infants has utilized the contrast sensitivity measure. This is tested by the lowest contrast at which a grating of a particular spatial frequency can be discriminated from a uniform field. The contrast varies with spatial frequency described:

> "... in terms of the coarseness of pattern information. Low spatial frequencies correspond to coarse pattern information such as the outline shape of large objects. High spatial frequencies, ... correspond to fine pattern information such as the texture of a surface". (Banks, Stephens & Hartmann, 1981, p. 502).

This relationship is indicated by the contrast sensitivity function. In fact acuity corresponds to one point on this function: the highest spatial frequency at which a grating contrast of 100% is necessary for detection, and above which no finer grating can be seen whatever is its contrast.

A number of visual recognition and discrimination tasks depend on contrast sensitivity at spatial frequencies below the acuity limit, as much as on acuity per se. Though both measures are important, the contrast sensitivity function has been demonstrated to yield valuable information about visual mechanisms that is not provided by acuity measures (see below for more details about the CSF approach).

1.1.1 Acuity

The acuity of the neonate has been assessed by the three following techniques: optokinetic nystagmus (OKN), preferential looking (PL) and visual evoked potentials (VEP). These procedures are referred to by their initials in the following sections.

These methods and some of the relevant studies on neonates are reviewed very briefly in this section (see Dobson and Teller, 1978, and Atkinson and Braddick, 1981a for a fuller discussion).

Optokinetic nystagmus refers to the eye movement patterns elicited by a succession of targets passing across the visual field. Eye movements consist of two parts: a) a slow fixation phase during which the eye smoothly follows the stimulus motion and b) a fast phase in which the eyes jump back in the opposite direction. These two involuntary phases follow each other in rapid alternation. Gorman et al. (1957), who tested neonates of 2 hours to 5 days of age, reported that OKN could be evoked in young infants. Ninety three of 100 infants exhibited OKN with stripes 34 mins of arc wide and none showed a response with stripes 10 mins of arc wide. These findings demonstrated that neonates are certainly not blind after birth. In another study Gorman et al (1959) found that all of 100 neonates tested responded to 20 mins/arc stripes. They all demonstrated acuity of 20/400 and many showed about 20/300. Similarly, Fantz et al., (1962) found that all 7 infants they examined under 1 month of age showed OKN to 20 min/arc stripe but none to 10 min/arc. Dayton et al.(1964) tested infants aged 8 hours to 10 days using a range of stripe widths. Only 56% of their subjects showed OKN with any of their patterns, although half of these responded to stripes as fine as 7.5 min/arc.

Studies which used OKN to measure grating acuity in infants indicated that OKN acuity is at least 20/400 in the newborn infant and improves as the infant grows older (e.g. Fantz et al., 1962), Kiff and Lepard, 1966). As noted by Dobson and Teller (1978) and Banks and Salapatek (1981) that studies which used large-field moving stripes to elicit OKN yielded almost similar average acuity values. Some of the difference in the results were due to variations in stimulus parameters (e.g. luminance, speed of movement) and in response measures.

Preferential looking

This technique requires that the subject's eyes are open with both eyes and head oriented towards the stimulus. Acuity is assessed on the basis of differential fixation to the various stimuli in the visual environment. Fantz et al. (1962) tested infants between 0 and 1 month and reported an acuity of 20 min of arc. Miranda (1970) found that infants in the first days of life could resolve 70 min/arc stripes. Recent research on acuity has adopted the forced-choice preferential looking technique (FPL), introduced by Teller (1974, 1979). This procedure necessitate the use of an observer, 'blind' to the position of the stripes who has to make a forced-choice judgment about which side the stripes are on from observation of the infant's behaviour. Teller et al. (1974) reported the acuity values similar to those of Fantz et al. (1962) at both the higher and lower luminance values.

A more refined study by Allen (1978) tested infants from 2 weeks to 6 months of age. An acuity of 27 min/arc was noted at 2 weeks and the average acuity values agree with those values found by Teller et al. (1974) at the same luminance.

Salapatek, Bechtold and Bushnell (1976) judged direction of first fixation to estimate acuity at 30, 60, 90 and 150 cm in 1-2 month olds. The results showed no difference in acuity as a function of age or distance. Banks and Salapatek (1976, 1978) who used PL to study contrast sensitivity functions in 1 - 3 month-old infants estimated acuity from the cut-off frequency of the resulting contrast sensitivity function. The infant's first fixation was toward the grating on 75% of the trials.

The estimates of acuity obtained were similar to those of Allen (1978) for 1 month-olds and Teller et al (1974) and Allen (1978) for 2 and 3 month-old infants.

Atkinson, Braddick and Braddick (1974) and Atkinson, Braddick and Moar (1977a, b) tested 1, 2 and 3 month-old infants. They recorded the direction of first fixation and adopted the FPL procedure to obtain the contrast sensitivity functions. The acuity estimates (cut-off frequencies) obtained for ten 2 month-old and eight 3 month-old infants are similar to those reported by Banks and Salapatek. The average acuity values for eight 1 month-old infants, is lower than the value found by Banks and Salapatek for 1 month-old infants.

Evidence from the above studies indicates a good agreement in acuity values obtained with stationary stimuli and with flashing and drifting (Atkinson et al., 1977, a, b, Dobson et al., 1978) and similar conditions of stimulus luminance even when different variants of the PL technique are used.

Visual evoked potentials

The VEP is a summed cortical response which results from a temporal change in some characteristic (e.g. intensity of the visual stimulus impinging upon the eye). Most of the research on neonates has used this technique, which indicates that the visual pathway is functioning and shows a sharply decreasing latency of response with increasing age (Ferris et al., 1967).

Harter and Suit (1978) tested one infant between the 21st and 156th days of life. The stimuli were flashing checkerboards of various check size. When the infant was between 21 and 35 days of age, they found that the VEP amplitude did not vary with check size. After 35 days the stimulus size eliciting the maximum VEP amplitude decreased consistently with age. As in Harter and White (1970) the infant's responses were compared to those of adults. They reported that the data of 1 month-old infants corresponded well with the results shown by adults blurred to a Snellen acuity of 20/500, and data from the infant at 3 months were similar to those of adults blurred to 20/250 acuity.

Harter et al. (1977a, b) measured transient VEPs in newborns between the ages of 6 and 45 days, using as stimulus flash-illuminated black and white checkerboards, with individual checks subtending 10, 20, 45, 90 and 180 min/arc. At all ages infants demonstrated a peak amplitude when either 10 or 20 min checks were presented. These results suggest that even the very young infant's visual system is capable of responding to stimuli indicative of 20/200 to 20/400 acuity. Harter, however, noted that these findings may not be a good indicator of functional acuity in infants as the peak amplitude. P_2

(major positive waves of the transient VEP) did not change with age over the range studied, whereas behavioural and OKN studies find an increase in acuity during the first 2 months.

Atkinson et al. (1979) using rapid (10 HZ pattern reversal, found a limiting stripe width of 35 min/arc in infants aged between 1 and 10 days old, and 25 min/arc in 3 week-old infants. Marg et al. (1976) reported VEPs from appearance of 25 min/arc stripes in 1 month-old infants.

In the neonatal period, the different techniques converge on quite similar values of acuity, with support for an estimate of 30 min/arc at birth and better acuity (15 - 20 min/arc) at 1 month (see Dobson and Teller, 1978). The variation in estimates from study to another may be due largely to differences in experimental techniques. Comparison of the results obtained using the three response measures indicates that the VEP studies generally obtained higher acuity estimates than either the OKN or preferential looking studies (see Banks & Salapatek, 1985). However, it is also true that within each method there are wide-ranging and overlapping estimates made. Dobson and Teller (1978) suggested that the difference in acuity estimates is perhaps due to discrepancies in the criteria for what constitutes threshold. While the criteria in OKN and preferential looking studies have been stricter, the criteria in VEP acuity studies have been rather lax. Atkinson et al. (1979) compared infant acuity estimates obtained using the fixation preference paradigm and the visually evoked response. They reported that the two techniques gave similar acuity estimates once differences in threshold criteria were minimized. This finding supports the suggestion that the absence of differential responding in the preference paradigm is associated with an inability to discriminate two stimuli. Research on premature infants (Fantz et al., 1975; Dobson et al., 1980) indicated that performance on PL acuity tests is a function of gestational rather than postnatal age, indicating that at least the early stages of this improvement are due to a process of maturation.

Summary

Acuity (the highest spatial frequency an observer can detect) is quite poor in early life, in comparison to the adult's acuity. Thus, the ability to resolve pattern information is present at birth but is limited, and it improves with age at least partly as a result of maturation of the visual system. The three techniques have demonstrated that infant acuity can be meaningfully estimated in several ways, and that it improved considerably over the first 6 months of life. Some difference in absolute acuity values remain across techniques. Future research should investigate the influence of stimulus parameters, explore the extent of individual differences, and test the same age groups to refine these procedures.

1.1.2 Contrast sensitivity

The second line of research discussed is based on the contrast sensitivity function and linear systems analysis. The CSF approach is considered by researchers to be appropriate to detection and preference. The major reason for the usefulness of the CSF is its potential generality. Using this model, psychophysicists employed the data obtained with a limited set of patterns to generalize predictions such as how detectable other types of patterns are to adults (Ratliff, 1965; Davidson, 1966; Cornsweet, 1970). The CSF approach has been used to study adult pattern vision, but was only recently applied to infant vision.

The contrast sensitivity function plots the contrast required to just detect a sinusoidal grating as a function of spatial frequency. Figure 1A (below) shows a sinusoidal grating whose spatial frequency is increasing from left to right and whose contrast is increasing from top to bottom (Banks, 1985, p.41). The ability to detect the grating varies with spatial frequency. Medium frequencies are easier to detect than highs or lows. Figure 1B shows a typical adult CSF (Banks, 1985, p.41).

Fig. 1A

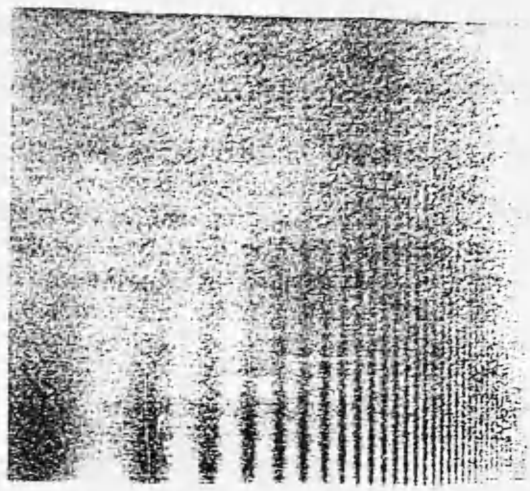


Fig. 1B

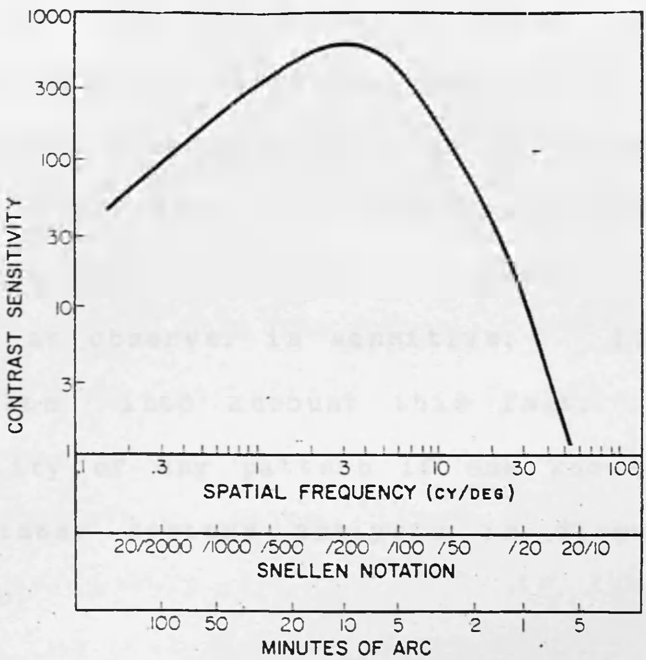


Figure 2. A sinusoidal grating varying in spatial frequency and contrast, and a typical adult contrast-sensitivity function. The upper half of the figure shows a grating whose spatial frequency increases from left to right and whose contrast increases from top to bottom. The lower half of the figure shows a typical adult contrast-sensitivity function. Contrast sensitivity (the reciprocal of contrast at threshold) is plotted as a function of spatial frequency (in cycles per degree—adapted from Cornsweet, 1970).

An estimate of a visual system's sensitivity function to various sine wave gratings can be obtained by measuring the CSF. The CSF represents sensitivity to gratings of different spatial frequencies. Sine wave gratings are described by 4 properties: spatial frequency, contrast, orientation and phase (see Banks & Salapatek, 1981).

The theories behind the CSF model are Fourier's theorem and linear systems analysis. Briefly, Fourier's theorem posits that any two-dimensional stimulus (e.g. a picture of a face) can be described exactly by the combination of a set of sine wave gratings of different spatial frequencies, contrasts, orientations and phases. Accordingly, the CSF characterizes the pattern information to which an observer is sensitive. Linear Systems Analysis takes into account this fact. It predicts the visibility of any pattern if one knows the observer's CSF. Linear systems analysis is discussed below in more details.

Before reviewing studies which measured CSFs in young infants, it is useful to know what is the low-frequency attenuation first as these studies investigated also the low-frequency sensitivity.

Adults' sensitivity to low spatial frequencies is lower than it is to intermediate frequencies. In other words, the adult visual system is not very sensitive to low spatial frequencies. Thus, the adult CSF exhibits a low-frequency falloff in sensitivity. Ratliff (1965) and Cornsweet (1970) among others have discussed the functional significance of the low-frequency falloff in sensitivity. Low-frequency insensitivity is often assumed to be due to lateral inhibitory processing in the visual system. Lateral inhibitory processing relates to inhibitory interactions between neural elements which is commonplace in the vertebrate retina (Cornsweet, 1970; Ratliff, 1965). Evidence from physiological studies suggests that the magnitude of lateral inhibition in the retina is less for low luminances than for high luminances (Barlow, Fitzhugh & Kuffler, 1957; Enroth-Cugell & Robson, 1966). It is also known from human adult psychophysiological research that the slope of the CSF's low-frequency falloff is positively correlated with stimulus luminance (Van Nes & Bouman, 1965). Thus, a number of investigators (e.g. Kelly, 1975) have argued that the CSF's low frequency falloff reflects lateral inhibitory processing and that changes in the falloff with changes in stimulus luminance reflect changes in the magnitude of lateral inhibition.

There is a vast amount of information in the adult's retinal image. To simplify processing of the image, the nervous system filters and selects certain types of information. Lateral inhibition is an integral part of this filtering process. The pattern information which passes through lateral inhibitory networks seems to be that which is most involved in pattern processing; these networks emphasize areas of transition in intensity (sharp intensity gradients such as contours) in the retinal image by attenuating or deemphasizing gradual intensity gradients (such as diffuse shadows). By making the visual system relatively insensitive to low spatial frequencies, lateral inhibition serves to increase the visibility of sharp changes in illumination (edges). This latter is considered to facilitate the process of form perception by enhancing the visibility of the contours of forms (Cornsweet, 1970). This contour-emphasizing process seems not to be present during the first weeks of life and must therefore develop postnatally. Thus, the appearance of the low-frequency cut between 1 and 2 month presumably shows the functional emergence of this important feature of retinal organization.

The assumption that the low-frequency fall-off in the CSF is the result of lateral inhibitory processing in the visual system has been questioned (see Hoekstra, Van den Brink and Bilsen, 1974). The critics of the interpretation indicated that stimulus field size is fixed in most CSF studies, and the number of bars (cycles) presented is inversely proportional to the spatial frequency of the grating. In other words, only a limited number of cycles or bars of low-frequency gratings is presented. The argument proposed is that the low-frequency attenuation generally found in CSF studies may be due to the limited number of cycles in low-frequency gratings, therefore such attenuation is an experimental artifact and not a manifestation of lateral inhibition.

Recent evidence however, supports the hypothesis that the low-frequency fall-off in the CSF is the result of lateral inhibitory process. Estevez & Cavonius (1976) measured CSFs for gratings that were equated for number of cycles regardless of spatial frequency. They found a low-frequency falloff and suggested that low-frequency attenuation in the CSF reflects lateral inhibitory processing in the visual system.

A number of research groups have assessed CSFs in young infants. Atkinson, Braddick and colleagues have used preferential looking and evoked-potential techniques to measure CSFs in infants from a few days to 6 months of age (Atkinson et al., 1979; Atkinson et al., 1977a, 1977b; Harris et al., 1976). Pirchio and colleagues (1978) measured the CSFs in 2 to 10 month-olds using evoked potentials, and Banks and Salapatek (1978, 1981), and Slater et al. (1985), adopted a preferential looking technique to measure CSFs in 1 to 3 month-olds and newborns. Some of these studies are discussed briefly below. It should be noted that the infant contrast sensitivity function has been the subject of only a few studies in newborns (Atkinson et al., 1979 and Slater et al., 1985).

Preferential-looking and visual evoked potentials

Atkinson, Braddick and Moar (1977a) attempted to see whether there were changes in sensitivity as measured by preference over the first 3 months of life and to see whether there was evidence of a low-frequency cut in infants younger than 2 months. The stimuli were static and drifting (3-HZ) sinusoidal gratings. Contrast sensitivity functions have been obtained for infants aged 5-12 weeks. At this age, infants can detect contrasts in patterns. However, there were large differences between the 5-week group and older age groups (8 and 12-week groups) in terms of extent of overall sensitivity and low-frequency cut. The 5 week group did not show a low-frequency cut.

In a second study, Atkinson et al. (1977b) used a first fixation measure to assess contrast sensitivity of 1, 2, and 3 month-old infants for stationary and drifting (3-HZ) sinusoidal gratings. On each trial, sine wave gratings appeared on one of two oscilloscopes; the other oscilloscope presented a uniform field of the same hue and average luminance. Each display was circular and subtented 15 deg. They found average peak contrast sensitivities of about 2.4, 5.5 and 10.4 at 1, 2 and 3 months, respectively. The results indicated a large increase in contrast sensitivity, particularly at high spatial frequencies, from 1 to 2 months and essentially no change from 2 to 3 months. The low-frequency fall in sensitivity that is characteristic of adult CSFs was not observed consistently at 1 month, but was shown at 2 and 3 months.

Atkinson et al (1979), who compared the two techniques on a single infant, reported a striking qualitative change in contrast sensitivity between 1 and 2 months of age. They assessed the contrast sensitivity function of neonates. Stimuli were sine-wave gratings which were phase-alternated at 10 HZ. Atkinson et al. found that peak contrast sensitivity for newborns is between 0.1 and 0.2 cy/deg, and for 5 week-olds it is between 0.2 and 0.5 cy/deg. At 2 months the contrast sensitivity function of the infant like that of the adult, demonstrates lower sensitivity to very low spatial frequencies than for intermediate frequencies. These results thus, support previous evidence suggesting a gradual improvement in contrast sensitivity over the first months.

Harris, Atkinson and Braddick (1976) measured CSFs in one 6 month-old infant. The two techniques (VEP and Preferential looking) yielded similar estimates of the CSF. The 6 month-old's CSF still exhibited a deficit in high-frequency sensitivity relative to adults. Thus, CSF development is not completed by the age of 6 month.

Visual evoked potential

Pirchio, Spenelli, Fiorentini and Maffei (1978) measured the CSF in one infant from two and a half to 6 months of age. In addition they assessed two points on the CSF (the high-frequency cut-off and the peak) in a number of infants from 2 to 10 months old. The sine wave gratings were presented in 7 to 25 deg fields depending on the infant's age. The gratings were flickered at a rate of 8 HZ. Threshold was estimated by plotting VEP amplitude versus contrast and extrapolating to find the contrast yielding zero amplitude. The results showed that contrast sensitivity and the low-frequency falloff increased notably with age. The low-frequency fall-off was observed at all three ages. The maximum contrast sensitivity increased and reached the adult value by the end of 12 months. Pirchio et al., concluded that visual functions are not fully developed at birth and the first year of life is critical for both the development of visual acuity and for reaching a normal contrast sensitivity at all spatial fequencies. At 2 to 3 months of age the infant's visual world is limited to large objects of high contrast (e.g. visual pictures which lack fine details) but insensitive to focussing. The two month and a half data were almost similar to the 2 months' results of the behavioural studies.

Preferential looking

Banks and Salapatek (1978) measured the CSF's of 1, 2, and 3 month-old infants. The response measure adopted was first fixation. They utilised a projection system to present much larger stimuli (40 deg x 40 deg) than Atkinson et al. (1977b). The grating and uniform fields were equal in hue (see explanation of hue below) and average luminance, but they were adjacent to one another. The experimenter waited until the infant was fixating midline before presenting the stimuli. The sine wave gratings were static. The results showed an increase with age in contrast sensitivity, primarily at high spatial frequencies, but not as large an increase as observed by Atkinson et al. (1977b). This increase in sensitivity to contrast was observed between 1 and 3 months of age. Also, the low-frequency falloff was not observed consistently at 1 month but was at 2 and 3 months. Figures 2A and 2B presented below show the group average data of Banks and Salapatek (Banks & Salapatek, 1978, p.361-365). Comparing the functions of Figure 2A to the adults' in Figure 2B indicates large differences. Infants' CSFs are shifted to lower spatial frequencies. The highest detectable frequency, the acuity cut-off, is a factor of 10-20 below the adults'. Similarly, infant CSFs show a large sensitivity deficit relative to adults. For Banks and Salapatek, this deficit suggests MATURATIONAL ~~motivational~~ differences between infants and adults, but the similarity of behavioural and evoked-potential results indicates that motivation is not the essential difference. Young infants are less sensitive than adults. They require greater contrast before they respond at all to many frequencies easily seen by adults. Even within the

Fig.2A

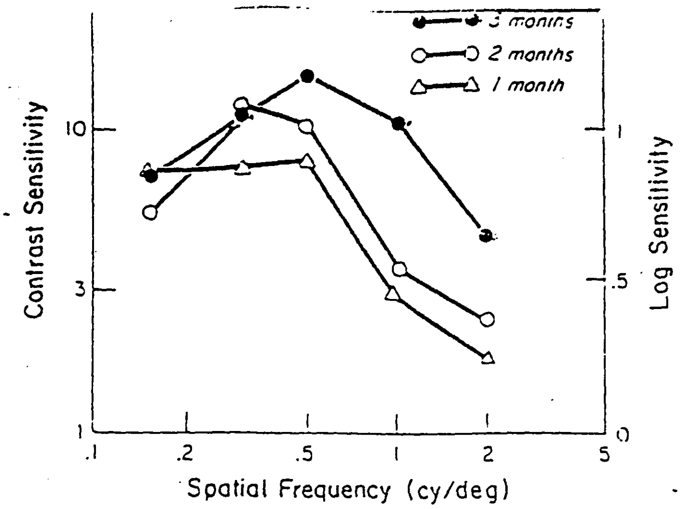


Fig. 1. Average CSF's for 1-, 2-, and 3-month-old infants. Contrast sensitivity (the reciproca. contrast threshold) is plotted as a function of spatial frequency. The logarithm of contr sensitivity is also shown.

Fig.2 B

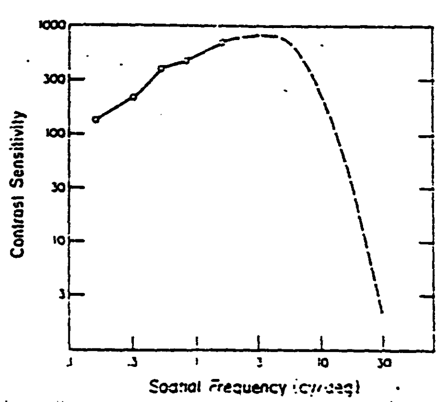


Fig. 2. CSF for an adult observer. The solid portion of the function represents data obtained with the infant apparatus. The broken portion of the function represents a typical high-frequency portion for an adult CSF under similar conditions.

first 2 months of age sensitivity improves. Infants start to respond to lower contrasts and to higher spatial frequencies.

Banks and Salapatek's Figures show that infants' acuity, sensitivity to contrast, and low-frequency attenuation become more adultlike across the first 3 months of life. This suggests that the development of these basic properties of form vision, improve rapidly during early infancy.

Banks and Salapatek (1981) carried out 2 experiments. In the first, they measured the CSFs of 1, 2, and 3 month-old infants using sine wave grating as stimuli. The response measure was a fixation preference. Maximum contrast sensitivity was higher in the 1 and 2 month-olds but still notably lower than the adults. The results indicated development between 1 and 3 months particularly in sensitivity to high spatial frequencies (fine stripes). At 3 months of age, sensitivity to high spatial frequencies was still quite low but higher than in the 1 and 2 month CSFs. The low-frequency attenuation characteristic of adult vision is observed at 2 and 3 months but not always at 1 month. In the second experiment, they measured the CSFs of 2 month-old infants at lower luminance level. A low-frequency attenuation became less pronounced than the one observed at the higher luminance. This decrease in the falloff's slope is similar to those observed in other adult psychophysical studies (e.g. Van Nes & Bouman, 1965).

Summary

The picture that emerges from this line of research is that the young infant's visual system is capable of detecting only large, high-contrast patterns in the environment. The young infant is sensitive to a much lower and perhaps a more restricted range of spatial frequencies than is the adult visual system. Further, the range of contrasts to which infants are sensitive is initially quite restricted. The ranges of detectable frequencies and of detectable contrasts increase steadily during the first half year. The low-frequency falloff between 2 and 3 months indicates the maturation of the visual system. One month-olds' results do not manifest lateral inhibitory processing but 2 to 3 month-old infants do.

The question that one should ask is how useful the linear systems model and CSF characterization of infant pattern vision is, and whether the linear system can predict infants' preferences for facelike patterns. The linear systems approach was used to accurately predict infants' responses to variously spaced high contrast stripes (Banks & Salapatek, 1981; Banks & Stephens, 1982; Slater et al., 1985) to checkerboards (Gayl et al., 1983), to patterns varying in the size and number of elements

(Rosinski, 1980) and to facelike and nonfacelike patterns (Kleiner, 1987). Some of these studies are reviewed below.

Banks and Salapatek's (1981) linear systems model assumes that infant preferential looking is governed by the pattern information available to "decision centers" in the central nervous system. There are two aspects of this assumption. First, the pattern information upon which the decision centers operate is only a small fraction of the information impinging on the infant's eye. Much information is lost in optical and neural processing by ocular media and visual pathways. This process of information loss can be considered as filtering. For Banks and Salapatek the CSF approach provides a way to determine what pattern information is processed by the decision centers.

Banks and Salapatek (1983) argued that the young infants' visual system is initially sensitive to only a fraction of the information to which the adult system is, and that this fraction increases steadily through at least the first half year of life. They referred to the fraction of pattern information to which young infants are sensitive as their "window". This window is quite restricted early in life. However, they insist that this does not suggest that infants are blind. First, regarding the low overall contrast sensitivity of infants relative to adults, the contours of a number of objects have contrasts greater than the threshold contrasts (see Banks & Salapatek, 1983, for more details). For instance, faces generally exhibit contrasts of 0.7 to 0.9 between the skin and hair, a value high enough to be detected by young infants. Therefore, though contrast sensitivity in infants is low compared to adults, it is sufficient for the detection of various intensity gradients. Concerning the shift of sensitivity to low spatial frequencies in infants, the spatial frequencies of the sine wave components in an object change systematically with viewing distance. At closer distance, the object's angular subtense increases and the major components are translated towards lower frequency values. The low frequency 'window' in young infants is best suited for perceiving objects in the immediate visual environment. As the 'window' grows with age, infants' capacity to perceive distant objects increase.

Second, Banks and Salapatek proposed that relatively simple decision rules are applied to this remaining information. Three rules are important. a) Young infants preferentially fixate the patterned stimulus which has the spatial frequency component of highest amplitude in the output amplitude spectrum. b) Young infants preferentially fixate the stimulus which has the greatest total energy in the output amplitude spectrum, that is decisions are based on the magnitude of the integral of (area under) the output spectrum. c) Young infants preferentially fixate the stimulus which, once filtered, possesses the greatest amount of contour density. Contour density refers to the total length of contour per unit of area multiplied by the contrasts of each of the contours. Regardless of the decision rule chosen, the model predicts developmental changes in pattern preferences due to changes in the pattern information sent to decision centers.

These rules are used to compute a predicted preference value for any two-dimensional pattern. Banks and Salapatek (1981) and Banks & Ginsburg (1985) tested the linear systems analysis by reanalyzing several pattern preference experiments in the literature. They computed predictions of the most preferred check size at 1, 2 and 3 month. The agreement between the data and the predictions of these rules was fairly reliable.

Banks and Ginsburg next examined the model's ability to predict preferences for different types of patterns. They used Maisel and Karmel's (1978) data on preferences of 5 and 9 week-olds for bull's eyes varying in the size and number of concentric rings, concentric squares, and checkerboards varying in check size and number. They used the 1 and 2 month CSFs of Banks and Salapatek for 5 week-olds and 9 week-olds. Again, the linear systems predictions were reliable.

Gayl et al. (1983) investigated Karmel's check-pattern preference data for 13 week-old infants, using Banks and Salapatek (1981) mean contrast sensitivity data for 3 month-olds and the spatial frequency amplitudes of the patterns to derive 3 metrics to infer the fixation times observed by Karmel. The amount of contour was found to be correlated with the spatial frequency content of a pattern. The increase in amount of contour corresponds to an increase in pattern energy toward higher spatial frequencies. Gayl et al. found that a rule similar to Banks and Ginsburg's square root of sums rule predicted looking times for Karmel's stimuli very well.

A study on newborn infants by Slater et al. (1985) provided strong support for Banks and Salapatek's (1981) findings that the most preferred stimuli are those which contain high amplitude spatial frequency components falling within the age group's peak contrast sensitivity. In their first and second experiments, Slater et al. used a visual preference method and showed infants pairs of stimuli that were equated for contour density but which differed in spatial frequency elements. In the third experiment, they used the infant-controlled habituation procedure. Preferences based on infants' peak contrast sensitivity could not be altered by habituating newborns either to the preferred or to the nonpreferred member of a stimulus pair. Large novelty preferences were found after habituating newborns to stimuli that were perceptually highly discriminable but where no preference had been noted prior to habituation.

Recently, Kleiner (1987) investigated whether the linear systems model could predict neonates preferences for facelike stimuli as accurately as it does for abstract patterns. The linear systems model would not predict a preference for facelike stimuli over other patterns except that the amplitude spectrum of the facelike pattern fit the infants' visual 'window' better than the pattern with which it is paired. This is because it claims that patterns with the greatest filtered amplitude will be most preferred, that is stimuli that are readily visible. Two day-old infants were presented with six pairings of 4 stimuli: a) a schematic face, b) a lattice, c) a pattern composed of the amplitude spectrum of the lattice and the phase spectrum of the face, and d) a pattern composed of the amplitude spectrum of the face and the phase spectrum of the lattice. Kleiner developed a method which dissociates phase and amplitude spectra. When the spectra are dissociated, the phase spectrum of one stimulus can be recombined with the amplitude spectrum of another stimulus, hence constituting a new pattern. Also, Kleiner adopted Piotrowski and Campbell's technique which combined the amplitude spectrum of a military tank with the phase spectrum of a face. For adult subjects the resulting pattern looked like a face and not a tank. Kleiner's results indicated that neonates' preferences were predicted from the amplitude spectrum and not from the phase spectrum. The correlation between the obtained preferences and those predicted by the linear systems model was 0.75. The obtained predicted correlation for the social hypothesis was 0.23. The neonates' looking behaviour was therefore determined more by stimulus energy.

The linear systems analysis model has been very successful in predicting the preferences of neonates and infants aged between 1 to 3 month-olds for various patterns. Though the contour density model of Karmel (1969) predicted 1 to 3 month-old preferences for the same patterns, it has not been as accurate as the linear systems model. The latter model is sensitive to many of the pattern manipulations that the contour density model is not sensitive to. The shape and arrangement of pattern elements influence a pattern's amplitude spectrum and thus, the predictions of the linear systems model but ~~not~~ they do not affect a pattern's contour density. Banks and Salapatek (1981) noted that both models, as they stand, are insentive to the meaning of a stimulus. Originally these models were developed as accounts for preferences among abstract non-representational patterns. Both models would not predict a strong preference for facelike over a similar, but nonfacelike pattern except to the degree that the facelike pattern provided spatial frequency or contour information that fit the infant's filter better. After 3 month of age neither the linear systems nor contour density view can account adequately for preference behaviour.

Preferences models in older infants would need to incorporate more developed attention mechanisms and longterm memory to account for the differential preferential preference between familiar and strange faces (Barrera & Maurer, 1981).

To conclude, infants' acuity, sensitivity to contrast, and low-frequency attenuation become more similar to the adult's during the first 3 months of life. These fundamental properties of form vision develop rapidly across early infancy. Acuity and sensitivity to contrast continue to develop beyond early infancy. However, the acuity and sensitivity values obtained by the third month are still below those of an adult. The linear systems analysis predicts accurately infants responses to abstract patterns as well to facelike patterns. Neonates prefer patterns whose filtered amplitude are greatest.

1.2 The visual pathways at birth

Acuity and contrast sensitivity are determined by: a) the quality of the optical image on the retina and b) the fidelity with which the image is represented by neural signals in the visual pathway. Thus the functioning of acuity and sensitivity indicates the maturity of both the optical and the neural components of the visual system.

From the retina there are two main pathways the visual signal can take. The primary pathway travels from the retina through the optic nerve and chiasm to the lateral geniculate nucleus (LGN) of the thalamus. From the LGN, there are projections to the occipital cortex (areas 17, 18 and 19) which join the temporal regions of the cortex. The second visual pathway projects from the retina to the superior colliculus within the midbrain; and from there to the higher cortial areas, directly and through the thalamus by way of the pulvinar. There are also pathways from the ~~otpic~~ OPTIC tract to the reticular formation, which project to a widely distributed area of the cortex.

Neurally, anatomical and physiological studies make it clear that considerable postnatal development occurs, though it is still not clear what any specific neural change implies in terms of visual function and behaviour. Mann (1964) claims that the fovea is poorly differentiated before 4 months, with fewer and stumpier cone receptors that in the adult and without the characteristic thinning of the ganglion cell layer. These factors are associated with the high acuity provided by the foveal region in adults.

At birth, the infant's optic nerve is both thinner and shorter than the adult's and not totally myelinated. These are estimations that the completion of myelinization range from 3 weeks (Last, 1968) to 4 months after birth (Duke-Elder and Cooke, 1963). Thus, myelination of the optic nerve is still proceeding from some time after birth, but how much effect it has on the quality of information transmission up the optic nerve is still not understood. In general, there is evidence that the primary visual pathways mature postnatally in a manner consistent with the order in which information is processed that is, the retina matures first, then the LGN, striate cortex, and so on, and that the secondary visual pathways develop faster and prior to the primary visual pathways (Bronson, 1974).

Evidence from animal research provided information about visual neural development (Blakemore, 1978). The receptive fields of retinal ganglion cells become more defined over the early weeks of life of kittens and monkeys (Rusoff, 1979) and the acuity reflected in responses of retinal and geniculate cells develops rapidly (Ikeda and Tremain, 1978; Blakemore and Vital-Durand, 1979). In the kitten's visual cortex only 1%, of the adult number of synapses are found around 9 days when the eye opens. These synapses allow cortical neurones to exhibit the characteristics of directional and orientational selectivity, and binocular organization that are present in the adult cat. It should be noted that the analogy to human infants must be used with caution.

1.3 Visual accommodation

The quality of the retinal image is governed by the physical parameters of the optics of the infant eye, and also by the accuracy of accommodation, that is how well those optics are behaviourally adjusted.

The optic medium is clear and the general optical quality is good as reported by ophthalmoscopic examination of the newborn eye. Duke-Elder, (1949) noted that refraction (the focus determined by the dimensions and optical power of the eye when accommodation is relaxed) is generally hypermetropic.

The eye can only be sharply focussed for one viewing distance at a time. The potential amplitude of accommodation is at its maximum in the early childhood, but it would be unlikely that the eye can focus on nearby objects unless accommodation can be properly controlled. Haynes et al. (1965) were amongst the first to study accommodation using dynamic retinoscopy. Infants under 1 month of age exhibited no accommodation. They kept their accommodation fixed at a focussing distance of about 20 cm. Improvement in accommodation occurred from 1 to 4 months. Recent research which adopted either a photographic procedure of testing instantaneous refractive state (Braddick et al., 1979) or retinoscopy (Banks, 1980; Brookman, 1980) reported that infants between 0 - 1 month of age are capable of adjusting their accommodation the approppriate direction for the distance. A significant percentage of younger infants (1 to 9 days) accurately adjusted for near distances (75 cm). Braddick et al., 1979). Older infants accommodated to both 75 and 150 cm distances. If the object is more distant their position of focus tends to be too close on average (Banks, 1980, Brookman, 1980) and demonstrates large fluctuations (Braddick et al., 1979). These results agree with those of Banks (1980b).

The findings of infant accommodation research indicate that considerable improvement in the accuracy of accommodation occurs between birth and 3 months. The capacity to focus to both distant and near targets develops in this period when acuity is also showing a rapid development, though no relationship between the two has been noted. Fantz et al., (1962) Salapatek et al., (1976) and Atkinson et al. (1977b) have found that 1 month acuity does not vary with target distance.

Most measurements of neonatal and 1 month acuity have been carried out with infants viewing at distances (20 - 50 cm) at which best focussing has been noted. For Atkinson & Braddick (1982) neonatal acuity is limited not by the optical blurring of the reginal image, but by the capacity of the immature nervous system to transmit spatial information.

1.4. Eye movements

The very center of the retina, the fovea possesses much higher visual acuity than more peripheral regions. When the eyes are stationary, the picture received has sharp detail only in its center and progressively less detail with greater distance from the center. Saccadic eye movements allow the effective visual field to be expanded by shifting the eyes from one position to another. When the subject attempts to hold fixation on a moving target (smooth pursuit and optokinetic eye movements), a different sort of eye movements occurs. Since the present thesis used stationary stimuli, only saccadic eye movements are discussed in this section.

Saccadic movements are present from birth. The initial saccade is always in the direction of a small target originally located on the peripheral retina (Harris & MacFarlane, 1974; Aslin & Salapatek, 1975; Lewis, Maurer and Kay, 1978). Aslin and Salapatek (1975) suggested that the young infant grossly undershoots the location of the peripheral target on this initial saccade. These undershoots may indicate that visual processing does not occur during each fixation, since many of them are only brief stops on the way to peripheral pattern elements (Aslin & Salapatek, 1975). Researchers disagree on the maturity of the retina at birth and its development during early infancy. Research on visual embryology (Duke-Elder and Cook, 1963; Mann, 1964 and Peiper, 1963) suggest that at birth the various neural layers have not been displayed from in front of the fovea and prevent direct stimulation of its high-resolution receptors. Also, it has been believed that the foveal cones of the newborn were shorter and subbier than those of adults.

It is until around the 4th month that the infant's fovea was basically equivalent to the adult's. As a result, the infant's central visual capacities were considered quite limited. This view is supported by Bronson (1974) and others. Bronson argued that the human nervous system includes a complex of mechanism for visual control of eye movements. In the newborn infant, both the macular area of the retina and the occipital-lobe response to primary-system input are less developed than is the peripheral retina. The central part of the retinal and neocortical components of the primary visual system undergo rapid development in the postnatal period - but just when foveally mediated primary system perception first becomes possible cannot be determined from the existing evidence. More recently, however, Haith (1978) reported a study of retinal develoment in rhesus monkeys by Ordy et al. (1965) showed that the monkey has a fairly well-developed fovea at birth. The degree of anatomical development of the retina at birth is still an open question.

To summarize, the saccadic eye movement system is functional at birth, allowing the newborn to localize stimuli of the central retina. The visual field for eliciting saccades develops postnatally. The latency to initiate a saccade is much longer in infants than in adults. However the neonatal saccadic eye movement system is less proficient than the adult system at directing the fovea rapidly to peripheral targets.

1.5 Distance and depth perception

Since distance and depth are two important dimensions in visual processing, relevant research is briefly discussed to help understand the neonate's visual capabilities.

Depth perception is the process by which the absolute and relative distances of objects are evaluated. The study of depth perception investigates how the human comes to see things in three-dimensions. The problem relates to the structure of the eye. The retinal surface on which optical images are projected is two-dimensional, thus it can only reveal the direction from which a beam of light comes and not the distance.

As the task of converting a two-dimensional representation into a three-dimensional percept is a problem, it is likely that the visual system uses various information sources: binocular, monocular, static and kinetic. For instance binocular disparity is a powerful depth cue but only for stimuli within a few meters of the subject some monocular depth cues require motion either by the observer or the object, and some do not. Kinetic information for depth is created by changes over time in the retinal image. These changes are produced by movements of the observer's head or body, or by the movements of objects in the environment.

Since the present research did not involve significant motion on any part of the stimuli or the subject's movements only static cues are reviewed.

Studies of the development of depth perception have been discussed by Pick and Pick (1970), Yonas and Pick (1975) Rosink (1977) and Aslin and Dumais (1980). Evidence indicates that 1 month old infants can discriminate three-dimensional from two-dimensional stimuli (Fantz, 1961). Greater heart rate decceleration occurred on the deep side of a visual cliff in 2 month-olds, indicating the ability to differentiate between the shallow and deep side (Campos et al., 1970).

To demonstrate depth perception as distinct from a sensitivity to properties of the image such as contour density which serve as depth cues for adults, it is useful to discriminate between stimulus convergence (equivalence is recognized between similar depth arrangements even when signalled by different cues) and response convergence (a stimulus evokes a response that implies localization in three-dimensional space, (Yonas & Pick, 1975)).

Research has been limited to the second of these. Bower et al. (1970a) and Ball and Tronick (1971) using optical projections whose motion SIMULATED ~~stimulated~~ an object approaching the infant reported avoidance responses such as head withdrawal indicating that the change of distance was registered as such. However it has proved difficult to differentiate between the supposed withdrawal response and a head movement following the upper moving contour of the moving object. There is some argument about whether this is a true depth response or a reaction to a rising contour. Other defensive responses such as blinking have been reported by Yonas et al. (1979). Neonates have been found sensitive to some properties of the stimulus that varies with distance (McKenie and Day, 1972, 1976). In these studies where the visual angle subtended by the stimulus was the same, no indication was provided of what the important cues could be.

1.6 Brightness versus hue

Since the present research controlled brightness cues it was seen advisable to discuss briefly brightness and colour perception in the neonatal period.

The term colour refers to the component of visual experience characterized by the attributes of hue, saturation and brightness. The first two attributes are chromatic and are related to the wavelength composition of the stimulus. Hue and saturation are the attributes most closely associated with the notion of colour.

There is only a moderate amount of research on colour vision in young infants and very little in neonates. Early studies which attempted to demonstrate chromatic vision that is discrimination of stimuli on the basis of hue and saturation (reviewed by Kessen, Haith & Salapatek, 1970, and Bornstein, 1978) failed to eliminate the possibility that infants were basing their discriminations on brightness cue rather than hue or saturation.

To rule out brightness artifacts, recent studies have examined the relationship between wavelengths and brightness, characterized by the spectral sensitivity function. The infants' (1 and 5 months of age) scotopic spectral sensitivity is similar in shape to adult sensitivity. Thus, the rods function early in life (Schneck and Teller, 1981; Wener, 1982). Some evidence suggests that the infants' (1 1/2 to 3 months) photopic spectral sensitivity is reasonably similar to adults (Fagan 1974). These results indicate the presence of normal cone functioning early in life, but do not ascertain that infants can discriminate on the basis of hue alone. Kessen et al., 1970, Munn, 1965; Oster, 1975; Schaller, 1975; Wooten, 1975) argued that equating brightness to adult standard is not an adequate control in tests of infant colour vision as it is unlikely that infants and adults have the same spectral sensitivity curves. Indeed evidence from Musinger and Banks (1974); Teller and Peeples (1974) and Dobson (1975) have shown that they are different. In these studies, they used spectral sensitivity data to match the brightnesses of their stimuli. Two to three month-old infants were able to make some dicriminations on the basis of hue alone. This suggests that young infants possess at least rudimentary chromatic vision.

Evidence indicates that by 2 and 3 months infant possess at least two cone systems (red and green) and make wavelength discriminations that adults with colour deficiencies cannot (Pulos et al., 1980; Hamer et al., 1982). However it does not suggest that infant's perception of brightness is identical to adult's. How far the neonate is capable of discriminating ~~eues~~ HUES is still not known. In addition, there is little evidence which can be brought to bear on colour vision in the first few days or weeks of life and it is not therefore clear to what extent such information could be important for face perception.

1.7 Neurally based theories of infant visual perception

Most of the aspects of visual behaviour discussed in this chapter are subject to changes between the first and third month of life, suggesting that the neonate's vision is different from that of an infant who is a few months older. The question about what basic developments are responsible for these changes and whether they have a common cause are still not answered. One way of explaining such developments is on the basis of the maturation of neural mechansism.

There are different versions of the two visual-systems theory (Bronson, 1974, 1982; Karmel and Maisel, 1975; Maurer & Lewis, 1979; Salaptek, 1975) and the cortical firing rate theory (Haith, 1980). Each of these makes predictions concerning early visual perception and its subsequent growth. Bronson (1974) suggested that early visual development can be characterized by differential rates of development among two parallel visual systems. Salapatek (1975) and Karmel and Maisel (1975) proposed similar models. These views are discussed briefly below and some evaluations are provided.

The primary visual system consists of the visual projection from the retina to the lateral geniculate and then to the visual cortex. The secondary visual system involves the visual projection to the superior colliculus. The description of the visual system as two prallel systems was made earlier by Held (1968), Schneider (1968) and was focal and ambient vision by Trevarthen (1968).

According to Bronson (1974, 1980) the components of the primary system are overrepresented in the fovea, have good visual acuity and respond selectively to changes in pattern variables (Shape, size, orientation, etc.). This system controls fine pattern analysis and stable binocular fixation. The components of the secondary system are not sensitive to changes in pattern variables and have poor acuity. They are sensitive to stimulus location and to temporal parameters such as stimulus onset and motion. This system allows the detection and localization of targets presented in the peripheral visual field, controls saccades to such targets and visual tracking of large targets. Bronson proposes that the secondary system which governs visual behaviour before 1 month of age matures more rapidly than the primary system which begins to play a role after the first 6 - 9 weeks.

The claim which Bronson makes that the retinal periphery is overrepresented in the secondary system is not true of other species. The superior colliculus of both cats and monkeys underrepresents the periphery relative to the fovea. Also, the direct retinal paths appear to overrepresent the fovea in monkeys (Schiller et al., 1974; Cowey & Perry, 1980). The notion that the fovea is poorly represented in the visual system shortly after birth could be true. Abramov et al (1982) reported that the neonate fovea is immature structurally compared to the parafovea. Thus the claim that the fovea is weakly represented at birth could be correct, but the cause is retinally based rather than collicularly based.

The proposition that the cortical and subcortical projections represent distinct parallel systems is probably not true as there appear to be interactions between the two projections (Banks & Salapatek, 1980). Bronson claims the existence of such interaction only at higher stages, but the properties of deep cells in the monkey's superior colliculus rely on cortical influence.

Further, evidence suggests that the development of the superior colliculus in cats does not usually precede the development of the visual cortex. Some cortical cells in kittens showed adultlike response properties before any collicular cells are sensitive to visual stimulation (Stein, et al., 1973b, Blackemore & Van Sluyters, 1975).

Bronson's main claim that the visual cortex and superior colliculus subserve different functions accords quite well with the anatomical and physiological results from animal studies. In general if Bronson's model is accurate the neonate should not be capable of visual discrimination based on pattern differences nor of visual memory and thus face discrimination and recognition would be most unlikely.

Maurer and Lewis (1979) placed their emphasis on the differences between X and Y type retinal ganglion cells. X cells project to the visual cortex, and show linear summation, high visual acuity and low temporal resolution. Y cells project to the visual cortex and superior colliculus. They govern different functions and exhibit non linear summation, high temporal resolution, and low visual acuity. X cells are specialised for fine pattern analysis and Y cells for the detection and localization of visual events.

Maurer and Lewis argue that only the X pathway to the cortex and the Y pathway to the cortex supposedly function between 1 and 2 months and also the Y pathway from the cortex to the colliculus. Thus both the visual cortex and superior colliculus are immature at birth and develop more mature functioning by the second month when the geniculocortical and corticotectal Y pathways become functional. They further assume that X projection to the visual cortex is operational at birth.

Banks and Salapatek (1983) argue that X and Y cells do not form two ditinct categories of cells but rather that the properties that differentiate the two cell "types" are distributed continuously rather than dichotomously (Lennie, 1980). As further evidence they point out that a number of cells of one type can be made to show properties of the other type by manipulating the adaption level of the cell (Lennie, 1980).

Maurer and Lewis' model is based on kitten data which showed distinction between X and Y cells (Daniels et al., 1978). Recent evidence suggests that the anatomical segregation of monkey X and Y cells is not as distinct as previously thought (Kaplan & Shapley, 1982), but it is distinct in cats. Even if X and Y cells are dichotomous in animals an extrapolation from cats to humans must be treated cautiously. Thus, according to Maurer and Lewis' (1979) view, patternn discrimination is possible at birth, and young infants should be able to respond to configuration as the X-cell pathway to cortex is functional.

Haith (1980), and Karmel and Maisel (1975), have suggested "cortical firing rate" models. These models claim that the visuomotor behaviour of young infants is guided by the magnitude of cortical firing. The neonate scans stimuli in such a way as to maximize some unspecified measure of cortical firing. The model claims that the visual cortex governs visuomotor behaviour in newborns. Further, the fovea is overrepresented in the cortical projection of newborns. The cortical firing rate would not be maximized by foveating a contour. Actually, recent anatomical evidence indicates that the newborn's fovea is less mature than other retinal areas (Abramov et al., 1982). For instance receptor packing density is lower in the fovea than in the parafovea. Apparently it is not likely that the neonate's foveal visual field is overrepresented in the cortical projection. It is perhaps only after postnatal receptor migration that the fovea becomes overrepresented.

Further, Karmel and Maisel have argued that contour density is a predictor of infant's preference. Since the evidence for this form of function is weaker for neonates than at later ages, discrimination between real faces is impossible in the first month of life.

Though these models present the weaknesses described above, they have been quite useful in guiding research in this field. In fact some of the evidence from studies accord quite well with the assumption of the two visual-system model, although more recent research does not agree with this theory's claims. The next section discusses the evidence on infant's response to faces.

1.8 Face Perception

There is an extensive literature on infants' perception of faces. This topic has been of interest to researchers from various perspectives. This section is restricted to the review of evidence regarding infants' response to faces and to face-like stimuli. The main question of concern is whether response to faces is on the basis of the whole configuration of the face, certain parts of the face (i.e. eyes) or physical properties of the face (i.e. contour or contrast).

(The author wishes to draw to the reader's attention that some of the details about the procedures adopted by the studies reported below are found in the methodological issues section and in Tables 1.1 and 1.2).

1.8.1 Evidence for an innate response to faceness

The first hypothesis proposed concerned the existence of an innate preference for human faces. Bowlby (1958) and other ethologically oriented investigators (Freedman, 1974; Goren, 1975) suggested the existence of an innate evolved preference for faces in human newborns. Goren et al. (1975) reported that a regular schematic face elicited greater visual following than scrambled or blank faces when the stimulus was slowly moved in an arc around the neonate, implying an innate differentiation of these stimuli. Further, newborns a few minutes (median age 9 mins) after birth followed a real face more than a mannequin or photograph. For Goren et al., the organized visual perception is an unlearned capacity of the human organism. "The infant enters the world predisposed to respond to a face, any face"(Goren et al., 1975, p.6). Maurer and Young (1983) who PARTIALLY ~~particularly~~ replicated Goren et al.,'s (1975) study did not find a general preference for "faceness". They used a similar procedure to that of Goren et al.,'s except they sat their newborn subjects in an infant seat rather than with the head supported on the experimenter's lap. In this study newborns were able to control their following without the experimenter's support. All babies followed each of the three patterned stimuli farther than the plain grey oval. This finding is similar to one of the results found by Goren et al., and gives support to suggestions that newborns are able to discriminate patterned from unpatterned stimuli. When Maurer and Young used the same experimental design as Goren et al., they found newborns followed with their eyes the natural drawing farther than one of the unnatural arrangements. No significant difference was found both in how far they followed the natural drawing and the second unnatural arrangement.

According to Maurer and Young newborns have some ability to discriminate between stimuli and between different patterned stimuli, but it is still early to credit the newborns with a general preference for "faceness". They explained the preference which the newborns showed as being based on the high contour density in the top of the natural drawing, on the integration of all its elements into a closer pattern, or on the horizontal orientation of five of its six elements.

It should however be pointed out that Maurer and Young used slightly older infants (range 12 hours - 5 days) and that more recent study using infants a few minutes old has confirmed Goren et al.'s results (Dziurawiecz & Ellis, 1986).

Thus, some evidence suggests an innate response to a natural drawing of a human face over distorted drawings. A few studies have reported this preference at birth and this evidence seems to contrast quite strongly with a body of research that argues for a much later development of a response to facial configuration. According to Gibson (1969), an important transition in the development of face perception occurs around 4 months. Infants become capable of noticing invariant relationships between facial aspects and respond to configuration of features rather than to individual features. Infants show spontaneous preferences, as demonstrated by longer fixations and smiling, for regular faces over faces with scrambled features though the basis of these preferences is not clear (Haaf and Bell, 1967; Kagan, 1967; Kagan et al., 1969; Thomas, 1973). More realistic versions of faces appear to be preferred over less realistic ones (Ahrens, 1954; Palak et al., 1964a,b; Kagan et al., 1966; Lewis et al., 1966; Kagan, 1967; Lewis, 1969; Wilox, 1969; Carpenter et al., 1970; Thomas, 1973; and Sherrod, 1979). Further, realistic faces are generally preferred over other nonface stimuli (Fantz and Nevis, 1967; Kagan and Lewis, 1965), (see Tables 1.1 and 1.2).

Thus, a number of studies suggest that around 4 months, infants are capable of responding to the facial configuration as a whole and not just to isolated features, and that the infant's response to facelike stimuli depends on how closely the stimulus looks like a human face. The above evidence has come from studies with some methodological weaknesses. For instance symmetry of the scrambled faces was not controlled and many studies used drawings. The adoption of more realistic versions of faces and objects is necessary for comparing the infants' attention to facial configuration at least in older infants with experience of real faces. Also, many different response measures were used and these may not all have been adequate or properly analyzed. For instance Thomas (1973), who objected to the procedure of averaging response measures, suggested the assessment of individual infant's preference functions. In this study, when individual preference orderings are examined, a preference for facelike stimuli was found in infants of 5 weeks of age. In a recent study, Thomas and Jones-Molfese (1977) used scaling analysis to show that 2, 3, 6, and 9 month olds' fixation times were related to a single dimension of faceness. The results showed a preference in ordering of 4 stimuli (blank oval, scrambled schematic face, regular schematic face, black and white photograph of a face) in infants from 2 to 9 months of age. At all ages, facelike stimuli were preferred. It should be noted however that although these scales could be based on facedness, they could alternatively be based on complexity.

Support for the claim that a faceness preference exists by 2-3 months of age has recently come from Kleiner and BANKS ~~Salapatek's~~ (1987) study. First, Kleiner (1987) examined whether neonates' preferences among facelike and abstract patterns are better predicted by the linear systems model (as indexed by the amplitude spectrum) or by the 'social hypothesis' (as indexed by the phase spectrum). According to the linear systems model, stimuli with the amplitude spectrum of the face would be preferred. The social hypothesis suggested that neonates would prefer patterns with the phase spectrum of the face, that is patterns that look like faces to adults. Two observers recorded the fixations. The fixation was scored when the reflection of the stimulus was centered on a neonate's cornea. Interobserver reliability was high (r=0.81). Two day-old infants were shown: a) a schematic face, b) a lattice, c) a pattern composed of the amplitude spectrum of the lattice and the phase spectrum of the face, and d) a pattern composed of the amplitude spectrum of the face and the phase spectrum of the lattice. Details about the procedures used are presented above, in Kleiner's (1987) study. The results indicated that infants' preferences could be predicted from knowledge of the amplitude spectrum but not the phase spectrum. Neonates' preferences for facelike patterns seem to be governed primarily by stimulus energy and not by the social significance or the familiarity of the stimulus.

In a second study, Kleiner and BANKS ~~Salapatek~~ (1987) investigated whether 2 month-old infants' preferences are governed by stimulus energy. The determinants of facial preferences were expected to change as the visual system matures and as the infant acquires more experience with faces. The infants were shown six pairings of 4 patterns. The stimuli and procedures were the same as those in the previous experiment. Two month-old infants preferred the facelike patterns even when the competing pattern had greater stimulus energy. This finding supports the suggestion that a faceness preference exists by 2-3 months of age. The 2 month-olds' preferences correlated with the phase spectra rather than with the amplitude spectra. For Kleiner & Salapatek facelike stimuli are fixated in early life because they have an amplitude spectrum that is preferred. Newborns may not have the visual capacity to respond to stimuli on the basis of their structure or their phase spectra. Preference for faces is governed by stimulus properties in neonates that are different from those in older infants. Accordingly, the preference shift from birth to 2 months of age may be a result of an increasing capacity to respond to stimulus structure and not the result of an increasing interest in facelike patterns. The suggestion that the developmental shift could be due to improvements in the ability to encode phase relationships is consistent with Braddick et al's. (1986) finding that 2 and 3 month-olds, but not 1 month-olds, can discriminate amongst simple patterns on the basis of phase differences.

1.8.2 Response to Complexity

The innateness hypothesis is not supported by a number of studies that have compared newborns' visual fixations of faces versus other stimuli. Reported preferences for looking at faces over other stimuli (Fantz, 1963; Stechler, 1964) can be attributed to a number of other variables especially complexity (defined by the number of elements). Evidence suggests that the infant's information processing capacity grows with age, and accordingly, that different levels of stimulus complexity provide optimal stimulation at different ages.

Haaf (1974) examined whether infants' response were related to stimulus complexity, faceness (the number of properly placed facial features), or both. He constructed 4 stimuli which varied in complexity and in faceness. A corneal reflection procedure was used. While 1 and 2 month-old infants fixated stimuli with a higher level of complexity, 4 and 5 month-olds responded to both complexity and to faceness. Two month-old infants demonstrated a linear increase for increasing levels of stimulus complexity. One month-old infants were reported to look longer at a natural face than at the other drawings because it was of optimal complexity.

Similar results were found by Haaf and Brown (1976) who examined the interaction of complexity and facial configuration and used different stimuli. Two month-old infants demonstrated a preference for increasing levels of complexity but seemed not to be attracted by the type of organization, facial or nonfacial. Four month-olds' fixation times were related to both the number of elements and to how they were organized. Haaf and Brown concluded that young infants do not regularly show a preference for the face over other stimuli, and they respond to the complexity rather than to the facial resemblance of facelike stimuli. A developmental shift at fifteen weeks from complexity to facial configuration was observed.

The possibility that complexity was a more salient dimension than facedness for young infants was investigated by Haaf, Smith and Smittey (1983). They tested the stimuli which Haaf employed in the previous experiment which varied independently in faceness and in complexity. Twelve week-old infants were shown four stimuli under three conditions: a "fixed trial" condition in which each stimulus was shown for 30 seconds, an "offset control" condition in which each stimulus was shown until the infant looked away from it for 2 seconds, and an "onset-offset control" condition in which each stimulus was shown when the infant was fixating the screen until the infant looked away for 2 seconds. The difference in procedure affected the infants' response to complexity. However, the infants' fixation times were not related systematically to the degree to which the stimuli resembled a human face. For Haaf et al. 2 month-olds respond to facedness only when stimuli do not also differ in complexity.

It is likely that complexity is a more salient dimension than facedness for young infants and as Haaf's stimuli varied in both, young infants might have responded only to complexity. Maurer replicated Haaf et al.'s offset condition with the version of the infant control method which Cohen suggested and which she and Barrera (1981) employed in their initial research. The stimulus was kept on the screen during each trial until the baby first looked away from it. Two month-old infants responded to both the complexity and to the facedness of the stimuli which Haaf constructed.

Another study which attempted to examine the possible interactions among facial characteristics (configuration, complexity, animation, and familiarity) was carried out by Sherrod (1979) who used total looking time as the dependent variable. The experiment was designed to allow consideration of the relative importance of each characteristic irrespective of any particular stimulus. Three groups of age were examined: one, three and five months. The infants were presented with a set of stimuli consisting of mother, stranger, a mannequin, a schematic face and a geometric stimulus. There were five examplars of each stimulus with the exception of mother who was specific to each subject. The mother was considered to be more familiar than the stranger, the stranger was assumed to be more animated than the mannequin, the mannequin was considered to be more complex than the schematic face, and the schematic face was assumed to be more facelike in terms of configuration than the geometric stimulus. Infants ranked the stimuli (according to length of fixations) as follows: stranger> mother> mannequin> schematic face> geometric stimulus.

For Sherrod the infants' ordering of the stimuli as such suggests the importance of animation and complexity in face preference. Infants at all ages preferred the complex animated faces. The preference for complex faces increased with age, a pattern which is congruent with the general development trend for response to complexity (Kessen et al., 1970).

The above evidence suggesting that infants respond to the complexity of the patterning of the face has come from studies which are not without methodological criticisms. For instance, Haaf's (1974) methodology was not appropriate. It can be considered as a test of relative dimensional salience since the dimensions of complexity and facial resemblance were not orthogonal to one another. Therefore, infants may have preferred the organization of facelike stimuli, but might have failed to respond when a highly salient dimension, such as complexity, attracted their attention. In Sherrod's (1979) study the findings might have resulted from the procedures utilised. The infants were shown 5 sets of stimuli in each of which the mother was included. With repeated presentation of the mother face, the infants might have habituated to the mother and their preferences to the novel face increased. The number of presentations together with the length of the trials (30 secs each) might have constituted a type of habituation paradigm which would explain the shift of preference for the stranger across trials. Thus, the infants response could be on the basis of novelty rather than complexity. A replication of this study on newborns with shorter trials and less stimuli (a single or paired presentation) is needed to find out whether infants would also show preference for the strange face.

1.8.3. Attention to facial Features

The second question concerns infants' attention to facial features. Specifically, whether infants respond to faces as a whole or to individual features. Evidence suggests that it is unlikely that infants less than 2 months old would recognize how the features of a human face are arranged and indicates that starting at 2 to 3 months the infant possesses many of the required skills. Infants of less than 2 months scan only a small portion of the face, mainly limited parts of the external contours and rarely fixate any internal features (e.g. Maurer & Salapatek, 1976; Haith, Bergman and Moore, 1977; Hainline, 1978; Maurer, 1981). Some of these studies and others are reviewed below.

Maurer and Salapatek (1976) used a corneal reflection technique to study how the infant of 1 and 2 months scans three real human faces: the mother's, a strange females's, and a strange male's. The infant was observed in his fixation of eight features. These features were: hairline, chin, right eye, left eye, mouth, nose, right ear, and left ear. The infant's visual behaviour was videotaped. A scorer replayed the videotape for each infant and judged from the reflections when the infant looked at a face and which of eight features he fixated. The scorer was blind as to the age of the subject he was scoring. When 1 month-olds fixated a face, they selected a limited portion of the perimeter. Two month-olds looked more at the faces, fixated more features and attended more to the internal features, particularly the eyes. For Maurer and Salapatek, 2 month-olds are more likely to look inside any object, and once inside they select the feature with the highest contrast. This explanation is supported by Salapatek's (1975) finding that 2 month-olds were more likely than 1 month-olds to look at a feature inside a square or circle.

Similarly, Haith, Bergman and Moore (1977) reported that infants between 5 and 7 weeks of age seemed to be attending to areas of high contrasts, especially the borders of the face. The visual fixations of 3 to 5, 7 and 9 to 11 week-old infants were recorded as they scanned the mother's and a stranger's face under three conditions: stationary, moving and talking. Infrared corneal reflection photographs were used. An infrared TV camera recorded the image of the eye with the reflections of the infrared lights. The position of the adult's eyes were measured on each face frame, and the positions of the centre of the infant's pupil and of the closest infrared reflection were recorded on the following eye frame. Computer programs calculated the distance of the face and the point of infant's fixations on it. While 3 to 5 week-olds spent much less time fixating the eye area and much more time in the edge regions, 7 week-olds and 9 to 11 week-olds both looked most often at the eye region. For Haith et al. the finding of edge attraction for 3 to 5 week-olds supports earlier findings of contour attraction in newborns.

The finding that at 5 weeks of age infants fixate those parts of the face with high degrees of contrast is supported also by Bushnell's (1982) results. Using an habituation / dishabituation procedure, he attempted to determine the process underlying mother-face discrimination and whether or not it is affected by the absence of specific feature information. Three age groups of infants (5, 12 and 19 week-olds) were tested. The infants were involved in five discriminations - between the photographed faces of mother and female stranger: 1) expressionless face 2) standardized eye area for both faces 3) standardized mouth for both faces 4) standardized hair across both faces 5) standardized eyes and hair across both faces. Infants of 5 weeks of age were found able to discriminate between the photographed face of their mother and that of a female stranger. The infants discriminated their mother's face in every condition except when hair, or the eyes and hair, were standardized. Until the 19th week the internal features remained inessential for face discrimination. At this age, standardising the eyes prevented discrimination. Bushnell concluded that at 5 weeks, hair-face outline information seem to be playing a crucial role in face discrimination. At this age infants seem to discriminate between faces on the basis of the external outline of the face. When the information of the hairline was removed dicrimination between faces became impossible.

Thus, evidence reviewed indicates that while 2 month-olds tend to look longer at internal features, lingering especially on the eyes, 1 month-olds fixate fewer parts of the face than 2 month-olds. Whether the eyes attract the 2 month-old's gaze because they acquire some special meaning or simply because they are the internal features with the most contrast, these results supported Gibson's (1969) view that the eyes are the first internal facial feature to be discriminated. Gibson's conclusion was based on evidence suggesting that the eyes were the first isolated part of the face sufficient to elicit smiling (e.g. Ahrens, 1954) and Wolff's (1963) reports that 3 and an half week-olds fixate the eyes in a real face.

One of the few systematic studies which examined the relative salience of a number of different facial features for infants is the one carried out by Caron,

Caron, Caldwell & Weiss (1973). They familiarized 4 to 5 month-old infants to a distorted schematic face, and measured recovery to a real face. They postulated that the extent of this recovery would establish the salience of the feature or organization of features affected. For 4 month-olds the eyes were a more salient feature than the nose-mouth-area. By 5 months the nose and mouth were also perceptually salient. Further, the appropriate location and symmetrical arrangement of the eyes was clearly accessible to 4 month-old infants to whom the outer contour was more salient than the inner face configuration. Five month-olds could detect the nose-mouth asymmetries, and the internal face was as noticeable as the outer face and hairline.

The suggestion that at 2 months infants fixate the internal features particularly the eyes was supported by Barrera and Maurer's(1981) results. They presented 2 month-old infants with a naturally drawn face followed by two faces in which the features had been deleted from either the top or bottom half of the face. An infant control procedure was used. Infants fixated the half of the face in which eyes and eyebrows were eliminated less than the naturally drawn face, or the face in which mouth and nose were eliminated. Two month-olds' preference for a naturally drawn face was interpreted on the basis of the presence or absence of the eyes and/or eyebrows, and was not influenced by the nose and mouth. These results are consistent with those of Wilcox's (1969) study in which infants between one and two months showed comparable preference for a drawing containing only eyes over a drawing containing only a mouth and nose.

The results of Barrera and Maurer give strong support to the suggestion that only 2 months and older can scan broadly and look at the details inside the face, and that the eyes capture the infants' attention at this age. Further, Barrera and Maurer's results are consistent with studies which measured infants CSFs (see above) and reported that between 2 and 3 months the infants' ability to detect contrast increases. Souther and Banks (1979) found that when a face is filtered according to the CSF of a 1 month-old, only gross contour information remains. Filtering by the 3 month-old's CSF leaves many of the internal features sufficiently discernable that the infant could pick out some details about the eyes and mouth.

In another experiment Maurer (1981) habituated two groups of 2 month-old infants to a drawing with either the nose eliminated and the eyes and eyebrows appropriately placed in the upper half of the face or to faces with mouth and nose eliminated and either the eyes/eyebrows placed in the lower half of the face or rearranged as a design in the upper half of the face. The procedure used was identical to the previous experiments. At the age of two months infants were capable of discriminating drawings with and without the mouth and nose present, and also drawings with the eyes and eyebrows placed properly, misplaced, or rotated. Like Caron et. (1973) Maurer (1981) agrees that to a young infant the eyes are a more salient feature of a face than are nose or mouth.

The infants' attraction to the eyes is not lessened if the mouth moves while talking. In fact, talking faces elicit more fixation upon the eyes in 7 to 11 week-old infants (Haith, Bergman and Moore, 1977). Details about this study were presented above. Three age groups were examined: 3 to 5 week-olds, 7 week-olds, and 9 to 11 week-olds. Eye contact was held constant across stimuli in this experiment. Haith et al., suggested that the motion of the mouth, which occurred during talking, might have led to the intensification of scanning in the eye area.

It is not simply the characteristics of colour, contrast, and movement which make eyes such an attractive feature for the infant. Attractiveness of the eyes may be attributed to a prepotency of eye contact, or to the possibility that the eyes have acquired a signal value in social communication.

Thus, a number of studies have shown that until 4 months, infants respond to faces on the basis of isolated features. Around 5-6 weeks of age they fixate the external contour. Two months and older infants look at the internal parts of the face, especially the eyes. Preference for the eyes is enhanced by the motion of the mouth during speech.

1.8.4 Response to Symmetry

Young infants may prefer a real face because their internal features are symmetrical, united by proximity and "common fate" and have an outside contour defined by "good continuation". Yet there is no evidence that the neonates' responses to a human face are based on symmetry or on good continuation. Even 4 month-old infants do not prefer symmetrically arranged patterns over asymmetrical patterns (Bornstein, Ferdinandsen and Gross, 1981; Fisher, Ferdinandsen and Bornstein, 1981). Apparently, at none of the ages tested are infants' preferences for facelike drawing related to symmetry (see Table 1.1). Around the 4th month, infants demonstrate evidence of identifying objects on the basis of common fate but they do not seem to define objects on the basis of good continuation (Kellman & Spelke, 1981).

1.8.5 Discrimination between real faces

Thus it is still equivocal whether infants have any innate sensitivity to the configuration of the face as such, or whether it is learned over the first month or two. But when can real faces actually be differentiated? Early evidence from studies suggests that discrimination between the real faces of individuals is possible after 2 months of age. Cornell (1974) using spontaneous visual preference found discrimination between male and female faces at 23 weeks but not at 19 weeks. Fagan (1972) using photographs of real faces noted discrimination only at 22 weeks but not at 17 weeks. Cohen et al. (1977) reported successful discrimination at 18 weeks. Infants were able to distinguish between two faces of the same sex or different sex. Also, Fitzgerald (1968) using achromatic video stills found discrimination between the faces of the mother and female stranger at 17 weeks but not at 5 and 9 weeks. Finally, Caldwell (1965) noted discrimination in infants of 13 weeks of age.

From the above studies it appears to be clear that early face discrimination is not possible. However, since these studies presented weaknesses regarding their procedures and stimuli, one has to be cautious when referring to their evidence. The use of achromatic photographs (e.g Fagan, 1972; Cornell, 1974 and Fitzgerald, 1968) instead of real faces might have affected the infant's visual behaviour. The adoption of autonomic pupillary reflex by Fitzgerald (1968) might have accounted for the results she reported. Also the short presentation of stimuli could have been responsible for Fagan's (1972) and Cornell's (1974) results.

These methodological factors may be especially important given there is evidence that infants can visually discriminate the real faces of adults (Carpenter, 1973; Carpenter, 1974; Maurer & Salapatek, 1976; Sherrod, 1979; Masi & Scott, 1983; and Field et al, 1984) or even between photographed familiar and strange faces (Bushnell, 1982) in the first month or week of life. Since these studies are related to the present research, it was decided to review them in greater detail (see Table 1.2).

Though Maurer and Salapatek's (1976) infants failed to demonstrate visual preference for the mother's face, their subjects were able to discriminate among faces at the age of 1 month and fixated their mother less than either stranger face. For Maurer and Salapatek, discrimination between faces was perhaps based on differences in the hairline or chin, since 1 month-olds rarely fixated other features, and since in two-dimensional shapes they seem to recognize changes along the border (Milewski, 1975). Two month-olds showed equal preferences for the mother and strangers'faces. Infants were presented with the faces of the mother, a female stanger and male stranger (see above for more details of this study).

Similar results were found by Sherrod (1979). One, three, and five month-olds showed preference for the strange female over the mother, a mannequin and a schematic face. Preference for the strange face increased with age.

Sherrod attributed the 1 month-olds' failure to differentiate between the mother and a stranger to the absence of voice cues (for more details, see above).

The first study to report discrimination of the photographed face of the mother from that of a female stranger at 1 month was by Bushnell (1982) who adopted a habituation-dishabituation technique and used life-size, colour slides of high quality. As mentioned in the review of Bushnell's study above, the basis of the discrimination between faces was attributed to the outer contours of the face which could have been the hair-face boundary the hair, the outer hair-head boundary or a combination.

Discrimination between faces of two different categories (familiar vs novel) was demonstrated even by preterm infants at 3-4 weeks of age. Masi and Scott (1983) habituated fullterm and preterm infants to the mother and stranger's face. Each one was given eight, 30-sec interaction trials of face presentations (four of mother and four of the stranger's face). During the test trials (30 secs each) the presentation of the mother and stranger's faces was accompanied by their voices. Both groups looked more at their mother's than at a stranger's face and the amount of fixation time for both fullterm and preterm infants increased with age. However fullterm infants showed stronger preferences for the mother's face than did preterm infants. This finding is consonnant with the evidence suggesting preterm infants are at least developmentally delayed in many aspects of functioning and with Field's (1977) result that at three and half months preterm infants averted their gaze more than fullterm infants when presented with their mother's real face.

Face discrimination in the first and second week of life was reported first by Carpenter, Tecce, Stechler and Friedman (1970) who examined infants' visual responses to human and humanoid "faces" using visual paradigm. Infants were presented with 1) a live human face (the mother's face), 2) a non-live female face (mannequin's face) and 3) an abstract form having some physical properties of the face. The live face of the mother was discriminated from the humanoid "faces" by two weeks of age. A linear increase in attention to the experimental stimuli over the first eight weeks of life was found. This increase in attention time and decrease in the non-attentive visual behaviours was interpreted by Carpenter et al., as an increase in the capacity to process visual information as a result of greater visual experience and/or development of the visual-perceptual apparatus.

In a second study, Carpenter (1973) observed the visual fixation time of 19 female infants once a week from age two weeks through seven weeks. Infants were shown the real faces of their mothers and that of a female stranger.

All infants were assigned to six condition: mother's face; female stranger's face (the experimenter's face); mother's face and voice; stranger's face and voice; mother's face and stranger's voice; stranger's face and mother's voice. Stimulus presentations lasted 30 seconds. Infants were able to discriminate the mother's face from that of the stranger's face at 2 weeks of age. Also, the mother's face, with accompanying voice, received more looking than mother's face without voice. For Carpenter, the visual responses: **"suggest relative withdrawal from strange or incongruous experience" (Carpenter, 1973, p.4)**. Carpenter attributed this early discrimination to very early learning.

Carpenter (1974), using the infant's mother's face; a caucasian mannequin's head; and a Negroid mannequin's head; tested females aged between 1-4 days for early face discrimination. The mother's face elicited greater fixations than the other stimuli. Attention increased linearly for the mother's face. This increase in attention was attributed to an increasing capacity to process visual information as a result of visual experience and/or to development of the visual-perceptual process (Carpenter, 1974).

Carpenter did not consider the possibility that the face with least reflectance would evoke least interest, nor did she allow for the possibility that the involuntary movement of facial muscles or eyes of the live face would capture the infant's attention.

More recently Field, Cohen, Garcia and Greenberg (1984) found discrimination between mother's and stranger's faces in newborn babies only a few hours (mean age 45 hours) after birth. In this study, they adopted the duration of the visual fixation to the faces (terminated by infant looking away defined as a 30 degrees head turn) as a dependent variable. Infants were first administered the Brazelton Neonatal Behavior Assessment (Brazelton, 1973) to elicit wakefulness and alertness. They then received a visual preference test, a series of habituation trials and a discrimination test. The visual preference test consisted of four trials during which the infant was shown the face (or the face and voice) of one of two strangers and the face (or face and voice) of his/her mother. An observer, blind to both the identity of the stimulus faces and duration of trials, was used to code the fixation times from the videotapes. Interobserver agreement based on live coding and the independent coder's timing of the videotapes visual fixations was 0.94. Infants showed a greater increase in looking at the stranger's face following habituation to the mother's face. This result indicates that even the stranger's face can be learned a few hours after birth by the newborn infants, and gives more evidence to early face discrimination. Field et al., suggested that newborns may learn in the few hours of life some distinctive features of the mother's face.

Voice cues were reported to enhance face discrimination by a number of researchers. Carpenter (1973) found no difference between infants' response to mother's face-voice combinations and mother's face-unfamiliar voice combinations. However, pooled face and voice combinations were better discriminated from faces without voices. The mother's face with a voice received more fixations than mother's face without voice. Also, Carpenter reported a preference for stranger's face with a voice than stranger's face without voice. She concluded that multi- sensory input supports multiple categorization which mediates attention. Similarly, Field et al. (1984) reported that face and voice combined constituted a salient stimulus but only for female neonates. Overall, neonates demonstrated preference for their mother's face and voice both in the visual preference and discrimination tests.

This recent evidence of early face discrimination seems to contradict the two-visual system model claims that recognition and even discrimination of real faces is not possible in the first few months of birth. However, since these studies in turn suffer from methodological flaws one should be cautious in arguing against the two visual system model's assumptions on the basis of such evidence. For instance studies which adopted the colour slides (Bushnell, 1982) or mirror presentation of real faces (Maurer and Salapatek, 1976) might have eliminated the possibility of infants' use of olfactory information in the discrimination process but they restricted the generalization of their results only to two-dimensional stimuli.

Also, some studies which utilised real faces did not use good comparison stimuli (e.g. the human face vs mannequin and schematic face) such as in the case of Carpenter et al., (1970) and Sherrod (1979) which might have resulted in differences in brightness and contrasts among elements. In other research using real faces, different categories (male vs female) of faces were presented to the infants. For instance in the case of Maurer and Salapatek (1976) and Melhuish (1982) the male stranger had a beard whereas the females obviously did not. In these studies, the stimuli were not good comparisons.

Further, all studies which used real faces failed to control for the influence of olfactory information. The olfactory effect may not be important when faces are strange to the baby, though some adults wear more and stronger perfumes than others. As well there exist differences between people in the intensity of their biological odours, and these factors may be especially important when the distance between infant and stimuli is small.

In research where the mother's face was used (Carpenter et al., 1970; Carpenter, 1973, 1974; Masi & Scott, 1983; Field et al., 1984) infants could have used olfactory information in discriminating their mother. Evidence has indicated that the young infant is more likely to orient toward the maternal olfactory cues than toward the stranger's (e.g. Papousek, 1970; Macfarlane, 1975). Chapter 3.1 reviews evidence on the young infants capacity to discriminate odours.

In addition, in all these studies of the infants' discrimination between real faces brightness was not controlled across faces (e.g. Masi & Scott, 1983; Field et al., 1984). Thus one would expect that sometimes the stimulus faces were extremely different and some other times they were less discrepant. The use of too many different comparison stimuli could have affected the infants' visual behaviour in the case of Sherrod (1979) and Melhuish (1982).

Another difficulty of studies adopting real faces is they all used a limited number of strangers (e.g. Carpenter, 1974; Field et al., 1984) which might have exerted specific influence on the infant's visual behaviour. The use of comparable stranger for each subject tested would be necessary to elucidate the process of early face discrimination. The use of a blind observers and coders is required to reduce bias on the part of both observers and coders.

1.8.6 Sex differences

Female infants exhibit greater attentiveness and more rapid habituation time to human faces. It could therefore be argued that females are likely to develop a differential percept of their mother's face earlier than boys. Also, they seem to be more capable of sustained attention than males and to prefer more complex stimuli (Kagan and Lewis, 1965; Haaf and Brown, 1976). The mother's face and voice as a combination elicits greater visual preference in female than in male newborns (Field et al., 1982). Kagan et al., interpreted their findings to demonstrate visual precocity in the females; whereas other experimenters reporting such sex differences are less willing to make such assertions, and indeed not all studies found that females have an advantage.

Sex differences were found not to be significant in other studies (e.g. Masi & Scott, 1983). When different measures (first and total fixation) were used, contradictory results were reported. While one measure indicated a significant sex difference effect with females showing more developed discrimination abilities than males, the other did not (Lewis et al., 1966). Other evidence indicated that males remain more responsive than females (Pancratz and Cohen, 1970; Cohen, Gelber and Lazar, 1971; Haith, 1966; Caron, 1968; Weizmann, Cohen and Pratt, 1971). Some investigators ignored a possible sex effect especially those who tested only one sex and generalized their results to both male and female infants (e.g., Carpenter, 1973, 1974).

Summary

As is often the case in psychological literature, there is conflicting evidence for sex differences. Few studies have included sex as a potential variable in early face discrimination, and those studies which analyzed sex differences have failed to report consistent findings.

Methodological issues.

The first point that should be noted is the level of agreement that exists between the results of studies that have used similar methods to explore the infants' visual interest in the human face. The consistency of findings of studies which used the same or comparable procedures provides some support for the suggestion that much of the confusion that exists in this area has arisen because data has come from studies which used quite different methods and have therefore been superficially contrasted with each other. Almost all findings of studies which used representations of faces have stressed facial configuration and complexity as determinant of face perception. Evidence from research which adopted real faces has emphasized the importance of the eyes, of animation and motion of the internal feaures of the face. Studies using real faces of the mother and that of a stranger reported preference for familiarity. The combination of familiarity with motion of the face or with voice cues attracts both newborns, 2- and 3-week-olds either when the stranger is a mannequin (Carpenter et al., 1970; Carpenter, 1974) or a human female (Masi & Scott, 1983). The smiling face of the mother is discriminated at 45 hours after birth from that of a female stranger (Field et al.,'s, 1984). Thus, the evidence that has formed the basis for the conclusion that it is only with increasing age that face discrimination is possible comes from different experimental procedures and it is likely that it is these experimental conditions which determine how newborns and young infants appear to respond to faces.

It is evident that the methodological problems seem to plague infants' face perception research. The <u>age</u> of the infants tested and the range of ages in a sample can be a significant source of variation. Different age levels have been examined and compared. The <u>sex</u> of infants tested is potentially important and either equal and unequal numbers of male and female infants have been used; or sometimes only one sex was examined (Carpenter et al., 1970; Carpenter, 1973; Carpenter, 1974). As reported above, the sex of the infant is itself a variable which influences the infant's visual behaviour. The <u>stimulus</u> type used appear to determine in part the infant's response. There is a great diversity in the type of stimulus employed, real face as opposed to schematic, three-dimensional or two-dimensional, chromatic or achromatic, life-size or smaller. Unlike photographs or two-dimensional shapes, real human faces are three-dimensional, a factor which affects other aspects of infants visual behaviour. While representional faces lack animation and many properties characterizing the live face (depth, brightness, colour, motion, odour etc), the real face has all these properties. Also, the live face has a specific odour. If not controlled, the olfactory modality may be involved in the discrimination process. Further, its effect is a function of distance from the target.

The method of stimulus presentation is crucial. Single and paired stimuli presentation have been used and while some evidence suggests that these two methods provide the same results (Greenberg & Weizmann, 1971) other evidence indicates that paired stimulus presentation is a less sensitive method for testing infants under 6 months (Ames and Silfen, 1965). Different response measures which frequently do not correlate highly with one another have often been employed. First fixation, longest or total fixation, (Fantz, 1966; Thomas, 1965; Brennan et al, 1966; 1979; Barrera & Maurer, 1981; Haith et al, 1977; Sherrod, 1979; Melhuish, 1982; Carpenter, 1974). Still other studies have adopted responses such as smiling (e.g., Spitz, 1946; Ahrens, 1954; Wolff, 1963). Head turning or orientation was used by Goren et al., 1975; Maurer & Young, 1983) and corneal reflection also has been used (Fitzgerald, 1968; Haaf, 1974; Haaf et al., 1983; Maurer, 1983). In some studies heartrate, bodily activity or any combination of the measures cited above (Kagan and Lewis, 1965; Kagan et al., 1966; Kagan et al., 1966; Haith et al, 1977; Carpenter et al., 1970) were adopted. **Various procedures** were utilised: habituation (Maurer & Barrera, 1978; Barrera & Maurer, 1981; Maurer, 1981; Masi & Scott, 1983), a combined visual preference and habituation (Field et al., 1984) or habituation-dishabituation (Bushnell, 1982; Caron et al., 1973). **Different lengths** of trials have been used: unlimited infant control, short trials and long trials. Finally stimuli have been presented at various viewing **distances.**

1.9 Memory in the neonatal period

To understand infant visual perception, one needs to know about visual recognition memory, specifically about the interactions between specific discrimination abilities and specific memory processes, as perception involves both dicrimination and memory.

In fact, studies of infants perceptual discrimination reviewed above, also provide information about infant recognition memory. For instance, if the novel and familiar stimuli are equally preferred at the onset of the testing, the only basis for the infant's differential response to the test stimuli is the difference in stimulus familiarity. Responding on the basis of familiarity also implies that the infant remembers some features of the familiar stimulus and necessitates that the infant encode or store information received during the familiarization phase for use in the testing and retrieves it to compare with subsequent inputs. Research on infant memory has examined what infants can remember, the earliest age at which they can remember and the susceptibility of their memory to interference.

Despite the importance which has been accorded to early experiences for subsequent development, there have been few studies on long-term memory in very young infants (Papousek, 1970; Little, 1970, 1973). In older infants retention is assessed by means of habituation-discrimination techniques (e.g. Cohen and Gelber, 1975) paired comparison paradigms (e.g. Fagan, 1970) or conditioning procedures (Little, 1970; Rovee and Fagan, 1976).

Cohen and Gelber's (1975) models used to assess recognition memory have been based on the Sokolovian (1963) model which proposed that greater attention to a novel stimulus indexes the extent to which the familiarized stimulus is remembered. After repeated presentation of the stimulus, the information becomes encoded as a neural trace. Thus, the salience of the stimulus will decrease and habituation of the organism's response system will result. Introduction of a new stimulus will produce increased attending. Infants who show rapid response decrement are those who build internal representations faster. If attention is equally distributed between the familiar and novel stimuli, or if response renewal occurs equally to both stimuli following habituation, a memory failure is inferred.

Cohen's (1973) model differentiates between attention getting and attention holding. Briefly, general stimulus variables (size, brightness, movement) influence, whether or not the infant will orient toward a stimulus. The specific information content of the stimulus (complexity, familiarity) determines how long the infant will continue to look. The act of fixation represents the initial phase of attention-holding processes, from which three steps follow. First, the stimulus information is analyzed by the perceptual processor into relevant stimulus dimensions. Second, abstract propositions of the stimulus information are formed and stored in memory. Third, the infant's fixation is a function of the operant conditioning mechanism which influence attention through the orienting reflex inhibitor-facilitator.

For Cohen habituation occurs as each component of the stimulus is processed and the representation formed in long term memory (LTM) becomes increasingly accurate. When the LTM model matches the external stimulus, the infant turns away and does not process the stimulus further the infant has habituated.

Cohen and Gelber (1975), Cohen (1976) found that infants as young as 2 months (perhaps even neonates) can habituate to a repeated visual stimulus and dishabituate to a novel one. In a very recent study, Slater et al. (1985) found that where no prior preference existed between two stimuli that are perceptually highly discriminable, strong novelty preferences were demonstrated by neonates of 12 to 7 days of age. However, the existing strong natural preferences based on the neonates' peak contrast sensitivity could not be changed by habituating the newborns either to the preferred or to the nonpreferred member of a stimulus pair.

Olson (1976) Fagan (1977) and McCall and McGhee (1977) among others also started with the assumption that the infant compares the test stimulus to information that has been stored from previous visual stimulation. They differ, however, in some issues. Briefly, these include the nature of the habituation process that is, is it gradual or all or none, do infants prefer the most novel stimulus or one of intermediate novelty? and the necessity of processing long- and short-term memory mechanisms.

These models present limitations. They all left out many unexplained points. For instance, Cohen & Gelber (1975) found the infant attention increase just before habituation but could not explain it. Also, they did not say how to measure rate of habituation. Further, these models ignored individual differences between infants.

Conditioning analyses are modelled after animal memory studies in which a distinctive response is trained in a given context and, at a later point in time, the experimenter tested whether such reponse is still produced. Retention is assessed in terms of responding during cued recall tests prior to the reintroduction of reinforcement (Davis and Rovee-Collier, 1979; Sullivan et al., 1979) or during reacquisition, in terms of savings (Little, 1973; for review see Rovee-Collier and Fagen, 1981).

Kaplan (1967) reported that 42 day-old infants fixated familiar stimuli for a significantly longer periods than novel stimuli. Werner and Siqueland (1978) found long-term retention for at least 24 hours. In a study by Little (1970) 20 day-old infants showed savings during reacquisiton 10 days after initial training, out performing 30 day-olds being trained for the first time. No evidence of retention was seen in 20 day-olds whose first session had occurred a 10 days of age. Thus, poor initial conditioning performance may have led to poor retention by the youngest group.

In general, information regarding infant memory is sparse. Conditioning analyses have provided evidence of lengthier retention at earlier ages. The results obtained from habituation studies which investigated infant visual discriminations are more likely to be influenced by the infant's memory ability than those obtained from visual preference studies. For this reason, habituation may be more suited for studying perceptual processes, and visual preference better suited for exploring discriminatory capacities.

Conclusion

The young infant is born with a partially functioning visual system and his/her visual capabilities develop significantly between the first and third month of life. Many changes occur 1) in acuity and in the low-spatial frequency cut shown in the contrast sensitivity function, 2) in visual accommodation, allowing the infant to focus on both distant and near targets, 3) infants become not only able to discriminate depth across distance, 4) but also they can differentiate on the basis of hue and brightness, 5) infants fixate internal as well as the external boundary and make even discriminations on the basis of internal aspects.

Yet the question concerning the basis of the infants' response to faces remains unanswered. There is only limited evidence for an innate preference for the human face. Only a few studies have found a preference for faceness at birth or at 1 month. Certainly by 4 months, and even perhaps earlier at 2 months (as shown in Kleiner and Banks's (1987) study) infants respond to the whole configuraton of the faces and features. At 1 month of age they fixate the outer contour and by 2 months they look at the internal features of face, especially the eyes. Also at this age they respond to only one or few isolated high contrast facial features and symmetry.

Discrimination between the real faces of human adults has been found to be possible by 1 month of age and even in the days after birth. The difference in age at which discrimination between faces from different categories (familiar vs novel) is possible may be due to the procedures and stimuli adopted in these studies. Future research designed to remedy the shortcomings of previous studies is required to further elucidate the early process of face discrimination.

Aims and hypothesis

The present research examines the question posed earlier in this chapter, that is, what is the earliest age at which face discrimination is possible using only visual information? Are infants able to discriminate between faces of different categories (familiar vs novel) in a spontaneous visual preference procedure, basing their discriminations on previous experience with the familiar face?

Table 1.1 A Summary of Studies Testing Infants' Preferences between Representations of Faces and Other stimuli (Studies in order of age of subjects)

Study	Age	Measure	Presentation	Trial Length	Results
Fantz, 1966	Newborns	First fixation time	Single	Unlimited infant control	Schematic = Nonfacial stimuli
Hershenson & Kessen & Messenger, 1967	Newborns	Total fixation time	Paired	--	Natural drawing = Distortions
Goren, Sarty & Wu, 1975	Newborns	Headturning Visual following	Single	--	Schematic face > Scrambled face> Plain grey grey oval
Maurer & Young, 1983	Newborns	Headturning Visual following	Single Single	--	Facial Stimuli > Plain grey oval Shematic face = Scrambled face = Plain grey
Maurer, 1983	Newborns	Total fixation	Single	Unlimited infant control	Facial > Nonfacial
Kleiner, 1987	Newborns	Total fixation time	Paired	10 secs	Nonfacelike patterns > facelike patterns
Fantz, 1966	1 week 1 month	First fixation	Single	Unlimited infant control	Schematic face = Nonfacial stimuli
Fantz & Nevis, 1966	2-4 weeks 1-2 months	Total fixation	Paired	20 secs	Schematic face = Nonfacial stimuli
Wilcox, 1969	1 month	Total fixation First fixation time	Single	18 secs	Natural drawn face = face with scrambled features

Haaf et al., 1974	1 month	Total fixation	Single successive presentation	30 secs	Natural drawn face > Other drawings
Maurer & Barrera, 1978	1 month	First fixation time	Single	Unlimited infant control	Natural drawn face > Scrambled arrangements
Sherrod, 1979	1 month	Total fixation	Paired	30 secs	Schematic face = geometrical stimuli
Maurer & Barrera, 1981	1 month	First fixation	Single	Unlimited infant control	Natural drawn face = Face with unnaturally symmetrically drawn features = face with unnaturally asymmetrical drawn features
Thomas, 1973	1 month	Total fixation time	Paired	20 secs	Regular schematic face £ Scrambled chematic face
Maurer & Barrera, 1981	2 months	First fixation time	Single	Unlimited infant control	Naturally drawn face = Unnaturally arranged face
Kleiner & Banks, 1987	2 months	Total fixation time	Paired	5 secs	Facelike patterns > Nonfacelike patterns
Wilcox, 1969	2 months, 2 weeks	Total fixation first fixation	Single	18 secs	Natural drawn face = face with scrambled features
Fantz, 1966	2-3 months	First fixation	Single	Unlimmited infant control	Schematic face = Nonface
Fantz & Nevis, 1967	2-3 months	Total fixation time	Paired	20 secs	Schematic face = Nonfacial stimuli
Lewis, 1969	3 months	First fixation time	Single	12 secs	Regular face = face with scrambled features
Sherrod, 1979	3 months	First fixation time	Faired	30 secs	Schematic face = geometrical stimuli
Wilcox, 1969	4 months	First fixation time	Single	18 secs	Natural drawn face = Face with scrambled features

Kagan, Henker, Hen-Tov	4 months	Total fixation time& Lewis, 1966 time Vocalization	Single	30 secs First fixation	Regular face = Scrambled face
Fantz & Nevis, 1967	5-6 months	Total fixation time	Paired	20 secs	Schematic face > Face with scrambled features
Kagan & Lewis, 1966	6 months	Total fixation time Bodily activity Cardiac rate	Single	30 secs	Schematic face > Blinking lights
Fantz, 1966	6 months	First fixation time	Single	Unlimited infant control	Schematic face > Bull's-eye, Newsprint
Jones-Molfese, 1975	2-6 months	Opernat response	Paired	180 secs	Regular schematic face £ Scrambled schematic face

Table 1.2 <u>A summary of Studies reporting Discrimination betwee real faces at 1 month of age and less</u>
(Studies in order of age of subjects)

Study	Age	Measure	Presentation	Trial Length	Results
Carpenter, 1974	Newborns	Total fixation time	Single	30 secs	Mother > Mannequin
Field, Cohen Garcia & Greenberg, 1984	Newborns	Total fixation time	Single	Unlimited infant control	Mother > Females stranger
Carpenter, 1973	2 weeks	Total fixation time	Single	30 secs	Mother > Stranger
Carpenter, Tecce, Stechler & Friedman, 1970	2 weeks	Total fixation time	Single	60 secs	Mother > Mannequin
Masi & Scott, 1983	3-4 weeks preterm 3-4 weeks fullterm	First fixation Total fixation time	Single	30 secs	Mother > Stranger
Bushnell, 1982	1 month	Total fixation time	Paired	30 secs	Mother > Stranger
Melhuish, 1982	1 month	Total fixation time	Single	30 secs	Mother < Stranger
Salapatek Maurer, 1976	1 month 2 months	Corneal reflection	Single	75 secs	Mother < Stranger mother > Stranger
Sherrod, 1979	1, 3 and 5 months	Total fixation time	Single	30 secs	Mother < Stranger

Chapter 2

EXPERIMENT (2.1) TESTING EARLY FACE RECOGNITION BY NEWBORN BABIES

Introduction

This chapter examines the question of very early face recognition. Can newborn infants actually discriminate their mother's live face from that of a non-parturient, non-lactating female stranger in the first hours following birth ?

Evidence from research using photographs of real faces indicated that face discrimination is not possible in the neonatal period. Fitzgerald (1968) who utilised achromatic video stills reported discrimination between the mother and stranger's face at 17 weeks, but none at 5 and 9 weeks. Similarly, Fagan (1972) adopted photographs and found recognition of faces at 22 weeks of age but no reliable discrimination at 17 weeks. Likewise, Cornell's (1974) 23 week-old infants were able to discriminate between photos of men versus women whereas 19 week-olds demonstrated no such recognition. Eighteen week-olds could successfully discriminate between two faces of the same and different sexes in a Recognition memory task (Fagan, 1976; Cohen, 1977; Cohen, Deloache & Pearl, 1977). Finally, Bushnell (1982) found discrimination of the mother's face from that of a female stranger from 5 weeks of age.

Though most of the above studies used habituation (Fagan, 1972; Cornell, 1974; Cohen et al., 1977), they demonstrated that infants are capable of remembering many features of the faces and of recognizing the familiar ones.

Studies adopting both real and representational faces reported earlier discrimination. Carpenter et al. (1970) who tested infants through the first 8 weeks of life found a significant preference for the mother's face from 2 weeks of age. Infants fixated their mother's face more than a mannequin's face. Also, the moving face of the mother was discriminated from the caucasian and negroid mannequin's faces at 2 weeks of age (Carpenter, 1974). Evidence from studies using real faces, however, indicated that face discrimination is possible at the age of 13 weeks (Caldwell, 1965); 5 weeks of age (Maurer & Salapatek, 1976); from 2 weeks of age (Carpenter, 1973) or even within the first 3 days of life (Field et al., 1984). This is the youngest age at which such discriminations have been demonstrated.

Thus there is a little evidence for recognition in the neonatal period. However this evidence does not accord well with the two visual system model (reviewed in chapter 1). Discrimination between real faces in the neonatal period should not be possible, as at this age, the cortical system of the infant is not yet developed. Although this model presents weaknesses it is unwise to argue against it on the basis of the available evidence, as this has come from research which suffers from shortcomings. In some cases the comparison of faces used was not good. For instance Carpenter et al. (1970, 1974) showed their subjects real faces vs mannequins of different colours (caucasian vs black). Maurer & Salapatek (1976) and Melhuish (1982) presented their subjects with male and female faces, thus involving the infants in discrimination of faces of different categories. Studies which reported face discrimination and identification in the neonatal period (Field et al., 1984) used single, successive long presentation of faces. The infants could have responded to faces showing a short term memory effect rather than recognition of the mother's face, especially since the neonates were habituated to the faces before the discrimination. Evidence reviewed in chapter 1 indicates that infants are capable of short and lengthier retention in the neonatal period.

One major difficulty related to the use of real faces is that all the studies discussed above failed to control for discrimination on the basis of brightness of the faces and particularly olfactory cues. These two variables may have influenced the above findings, and if controlled two questions would possibly be answered: the earliest age at which face discrimination is possible and what information does the young infant use in the discrimination process? Is it visual, olfactory or both?

The experiment described below was designed to explore the

Field et al.'s finding, since it has not been systematically confirmed by other researchers, using different procedures.

General Methodology

Procedure

Field et al. combined a visual preference and habituation paradigm in a smaller method to that used with 3 month-old infants by Barrera & Maurer (1981). Each infant was given a preference test with sequential presentation of the comparison faces. Each subject was shown one stimulus figure at a time until the neonate turned away from it. Next the mother's face or face plus voice was presented for repeated trials until the neonate reached a criterion of habituation. Habituation was considered as established when the infant looking time in each set of three consecutive trials decreased to less than half the looking time recorded by the observer for the first three trials. Then, the infant was given a discrimination test, involving two trials of a stranger's face and two of the mother's face. During the intertrial intervals separating the trials the infant's attention was retained using blinking coloured lights on the trap door.

Since the major aim of the present research was to study whether newborn infants demonstrate a preference for their mother's face over a stranger's, it was decided to use the spontaneous visual preference technique. This procedure was introduced by Staples (1932) to examine colour preferences in infancy and was later employed by Fantz (1961; 1962; 1964). Under this technique differential attention is regarded as an index of perceptual discrimination. Two stimuli (faces) are presented to the subject and the amount of time spent fixating each member of the pair is recorded. If the infant fixates significantly longer upon one stimulus than upon the other, it is concluded that he has manifested a preference for that stimulus, and that he has perceived differences between the two stimuli.

The spontaneous preference procedure seems to be attractive since it can be readily employed with newborns despite the restrictions imposed by their limited response repertoire. However, it has one limitation. When the differences in total fixation time to the two stimuli are significant the results are unambiguously interpreted. However, in the absence of such significance it cannot be assumed that the subject did not perceive differences between the two stimuli. This difficulty has been frequently reported in the literature (Gibson and Olum, 1960; Saayman, Ames and Moffett; 1964; Russel, 1965; Bruner, Olver and Greenfield, 1966).

Despite this limitation, the spontaneous visual preference procedure was adopted in the present research because it is more practical, easier to set up and less likely to lead to subject loss than is the familiarization procedure. This latter involves repeated presentation of a stimulus over a number of trials and can result in prolonged testing and adverse state changes.

The spontaneous preference technique was deemed appropriate because 1) it is quite simple to administer under Maternity Hospital conditions, 2) it involves no training of either the infant or mother and therefore does not interfere with their relationship or routine, 3) it is not time consuming for mother, infant or experimenter, 4) it need not involve more than two experimenters (the observer and the holder).

__Response measure__

While in Field et al. the measure of attention was the mean looking time of the two trials on which the face was presented, in the present study the dependent variable was the amount of time spent looking at the mother's face during each trial. This was obtained by accumulating the duration of the relative fixations to a criterion of 20 secs.

Fixation upon a stimulus was defined as occurring when the neonate infant oriented both his head and eyes towards the stimulus and after he settled his visual behaviour upon a stimulus figure.

In this research differential fixation presupposes visual preference and discrimination (Fantz, 1966). Though fixation as an index of "preference" has been criticized by other experimenters (Kagan, Henker, Hen-Tov, Levine and Lewis, 1966). The total fixation time to the mother's face, expressed as a percentage was used as the dependent variable in all experiments described in this thesis.

Reasons for the adoption of visual fixation

This measure was adopted because 1) it has been proved reliable by other investigators (Berlyne, 1958; Fantz, 1966; Cohen, 1969). Evidence suggests a high intercorrelation between the various measures of visual attention (McCall and Kagan, 1967; McGurk, 1971). 2) Because it does not involve much complicated equipment which can threaten both the infant and the mother.

Reliability of the observer's recordings

Observing infants is a quite difficult task, and recording visual fixation automatically is a very hard one. Therefore, reliability of data is usually questioned when recording of responses is not objective. In Field et al.'s study an observer blind to the hypothesis of the research, recorded the duration of the visual fixations on the faces through a periscope hole at the base of the chamber. A second observer videotaped the infant's behaviour to assess the reliability of the observer's recording. An independent observer, blind to the identity of the stimulus figure and to the duration of trials coded the tapes. Interobserver agreement based on live coding and the independent coder's timing of the videotaped fixations gave a Pearson correlation of 0.94.

In the present research which was conducted as an individual project, the use of a second observer throughout the whole testing as a check on observer reliability was not possible. Reports indicated that **"...unaided human observers can reliably observe the visual fixations of neonates"**(Miranda, 1970, p.4377).

Also studies using a similar method found a high interobserver reliability (e.g. Schaffer and Parry, 1969). In one study by Friedman et al., (1970a) who employed similar procedures with newborns, the judgements of time on stimulus made by two independent observers yielded a Pearson Product Moment Correlation of + 0.97 for 190 minutes of observation. An additional 202 minutes of observation using a new observer gave a Pearson Correlation of + 0.85. This high interobserver reliability corresponds with the level of reliability (0.98) reported by other researchers (e.g.McGurk, 1971).

Validity of the observer's recordings

In the present experiment there is a possibility of data being contaminated by observer bias (Rosenthal, 1963) but the resources to obviate this problem were not available.

Method

Subjects

The subjects were 20 (10 male and 10 female) Caucasian neonates, who were volunteered by their mothers on the wards of the Royal Maternity Hospital, Glasgow, Scotland. Their mean age was 51.29 hours, Sd = 7.81, (range 12.33-108 hours). The difference between male and female infants in age was not significant by t-test (t=-0.83, df=18, NS). Their mean birth weight was 3.57 Kg, Sd = 0.41 (range 2.89-4.42 Kg). The difference between male and female subjects in birth weight was also not significant by t-test (t=0.64, df=18, NS). **Table 2.1.1 presents the subjects' sex, age, birth weight and Apgar scores.**

Table 2.1.1 Subjects' sex, age, birth weight and Apgar scores (N=20)

Ss	Sex	Age (hrs)	Birth Weight (kg)	Apgar at: 1mn	5mn
1	M	16.34	3.92	8	10
2	M	20.15	3.69	7	9
3	M	23.33	3.98	5	8
4	M	25.30	3.80	9	10
5	M	27.04	4.42	9	9
6	M	27.15	3.10	9	10
7	M	48.20	3.20	6	8
8	M	52	3.57	8	9
9	M	101	3.37	9	10
10	M	107.05	3.26	9	9
11	F	12.33	3.75	8	10
12	F	18.6	2.89	7	10
13	F	33.38	3.99	7	9
14	F	34.05	2.96	9	10
15	F	38.09	3.40	8	9
16	F	50.15	3.85	9	10
17	F	85.36	3.37	9	10
18	F	95.17	4.13	7	9
19	F	103.12	3.46	9	10
20	F	108	3.32	9	10
Mean		51.29	3.57	8.05	9.45
SD		7.81	0.41	1.16	0.67

The subjects were selected from a population of apparently normal infants. They were full terms, healthy with no evidence of postnatal difficulties as judged by their Apgar scores at birth (see Appendix 2.1.) (mean Apgar at 1 minute after birth was 8.05, (range 5-9); mean Apgar at 5 minutes after birth was 9.45, range 8-10). Of the 20 subjects, the birth method of 15 was normal (SVD: spontaneous vertex delivery), 4 were sectioned (LUSCS: lower uterine segment caesarean section) and one was a forceps delivery (MCFD: mid cavity forceps delivery). For the experimental design 24 infants were tested. Of the 4 subjects who were excluded, one was discarded because of side bias in his looking behaviour (in this study side bias was defined as less than 5 sec looking at the least preferred side during the two test trials). Two were excluded because of baby fussing. One was discarded because the mother spoke during testing.

Stimuli / Apparatus

The faces (head, hair and neck) that the neonates viewed were the real faces of their own mother and that of a volunteer adult female. There were four non-parturient, non-lactating female strangers. One with black hair (Stranger 1), one with blonde hair (Stranger 2), one with medium brown hair (Stranger 3), and one with light brown hair (Stranger 4). These were paired randomly with mothers as in Field et al.'s study. The faces of two strangers (stranger 1 and stranger 2 were used nine times each. The faces of the third and fourth strangers were shown once each. The physical differences between the strangers faces and the mothers' faces varied nonsystematically across subjects. The difference between faces in brightness, however, could affect the direction of the results. This shortcoming will be addressed in the next experiments of Chapter 4.

The mother and the stranger were asked to sit behind a large white screen (2 x 2.5 m) hung as a curtain into which at head height were cut two apertures (30 x 25 cm) one to either side of midline and separated by 12 cm (see Fig 2.1.1 Photo of Apparatus). This procedure allowed a good view of both the faces of the mother and the stranger from the subject's position. In order to prevent any contamination of the results due to differences in the clothing of the mother and stranger, they each had a white sheet draped around their necks to effectively mask their clothing. A backcloth drawn behind the screen reduced irrelevant stimulation, and constituted a common background to both faces. Two fluorescent tubes above and in front of the faces illuminated them during the testing trials.

Figure 2.1.1 <u>Photo of Apparatus</u>

(This is an example of neonate being tested for recognition of the mother's full face. This neonate was actually not included in the sample). The mother is on the left hand side of the baby.

Procedure

The testing was conducted in the Hospital. The mother was provided with an explanation of the aim and procedures of the study before she was asked to participate with her baby in the experiment.

Contrary to Field et al.'s (1984) study in which infants were administered the Brazelton Neonatal Behavior Assessment (Brazelton, 1973) to elicit wakefulness, nothing was given to the infants in the present experiment. Only infants who were awake and alert on the wards were tested.

When calm and alert, the subject was brought from the wards to an adjacent, quiet room away from noise. An experimenter held the subject and attempted to maintain this optimal state. A white-coated observer stood centrally behind the faces and recorded fixations on a pair of buttons connected to a microcomputer. Whenever the subject looked at the right-hand stimulus face, the observer pressed the right-hand switch; similarly, the left-hand switch was pressed when the subject was fixating the left-hand stimulus face. Off-target visual behaviours included closing of eyes and turning the head and/or eyes away from the stimulus figure.

The discrimination test lasted 40 sec. There were two trials (20 sec each) for each subject. Each trial started once both stimulus figures had been satisfactorily instructed to adopt a neutral expression, to fixate the subject's eyes and to neither speak or make a sound nor move during the test trials.

The subject was introduced to the stimulus figures by being brought upright by an experimenter, into a seated position at a point 30 cm from the central point between the two faces. The holder was positioned so that the subject could see both faces. The subject's head was supported by the same experimenter but in such a way that it was left free to move in a lateral arc (see Fig 2.1.2 Photo of baby being held). The first trial started with the recording of the infant's fixation of either stimuli (faces) and ended after 20 sec fixation to either or both stimulus figures had been accumulated.

Fig. 2.1.2 Photo of baby being held

The central observer judged which one of the stimulus figures was fixated by the neonate and recorded the fixations on the microcomputer which provided an audible signal to indicate the trial ending.

After the first trial, the infant was withdrawn from the apparatus and the mother and stranger changed seats. This procedure was adopted to counterbalance the influence of side bias. Evidence suggests the existence of such an effect in neonates. Babies tend to prefer to look to the right side. This preference has been reported in 3 month-olds by Gesell and Ames (1947) and Turkewitz et al. (1965). The same procedure was repeated for the second trial until another 20 sec fixation had been accumulated.

A record form was used to list information concerning each of the subjects, the stimulus figures and their behaviour during testing. At the end of each session, information about the Apgar scores and maternal medication was collected from the Hospital files (see Appendix 2.1.2).

Results

It was hypothesized that infants would show a preference for the mother's face over the face of a female stranger. The amount of total fixations paid to the mother relative to the female stranger confirm this hypothesis.

Neonatal discrimination of mother's face from that of a female stranger

Fixation times for the paired stimuli shown during the discrimination test trials were compared for each subject. Preference for the mother and stranger were expressed in terms of percentage of total fixation time and were analyzed (see data in Table A below). The relative looking times are set out in Figure 2.1.3. Table 2.1.2 presents the mean percentage fixation times to the mother and to the stranger's face and the corresponding standard deviations.

Table A **Percentage fixation times (in seconds) for the mother and the stranger**

	Trial1		Trial2		Combined Trials	
	Stranger	Mother	Stranger	Mother	Stranger	Mother
Male						
	0.00	100.00	22.70	77.30	11.35	88.65
	52.55	47.45	21.50	78.50	37.05	62.95
	25.10	74.90	46.55	53.45	35.83	64.17
	35.20	64.80	0.00	100.00	17.63	82.37
	4.55	95.45	0.00	100.00	2.28	97.72
	32.10	67.90	2.10	97.90	17.13	82.87
	24.15	75.85	0.00	100.00	12.08	87.92
	76.80	23.20	9.40	90.60	43.13	56.87
	21.45	78.55	36.35	63.65	28.90	71.10
	32.20	67.80	23.75	76.25	27.98	72.02
Female						
	64.00	36.00	0.60	99.40	32.33	67.67
	59.60	40.40	93.37	6.25	76.70	23.30
	13.40	86.60	0.00	100.00	6.68	93.32
	69.75	30.25	63.15	36.85	66.48	33.52
	47.60	52.40	56.80	43.15	52.20	47.80
	39.60	60.40	52.55	47.45	46.05	53.95
	45.20	54.80	32.85	67.15	39.03	60.97
	6.65	93.35	46.50	53.50	26.60	73.40
	100.00	0.00	96.50	3.50	98.20	1.80
	10.35	89.65	57.35	42.65	33.85	66.15

Table 2.1.2 Means percentage fixation times to the mother on Trial1, Trial2 and on the combined Trials (N=20)

	Trials		
	Trial 1 %	Trial 2 %	Combined Trials %
Mean	61.2	66.9	64.4
Standard Deviation	26.64	30.60	24.02
Variance	709.896	936.40	577.2733
Average Deviation	21.30375	25.14475	17.45315
Coefficient of variance	42.98266	45.75938	67.53478

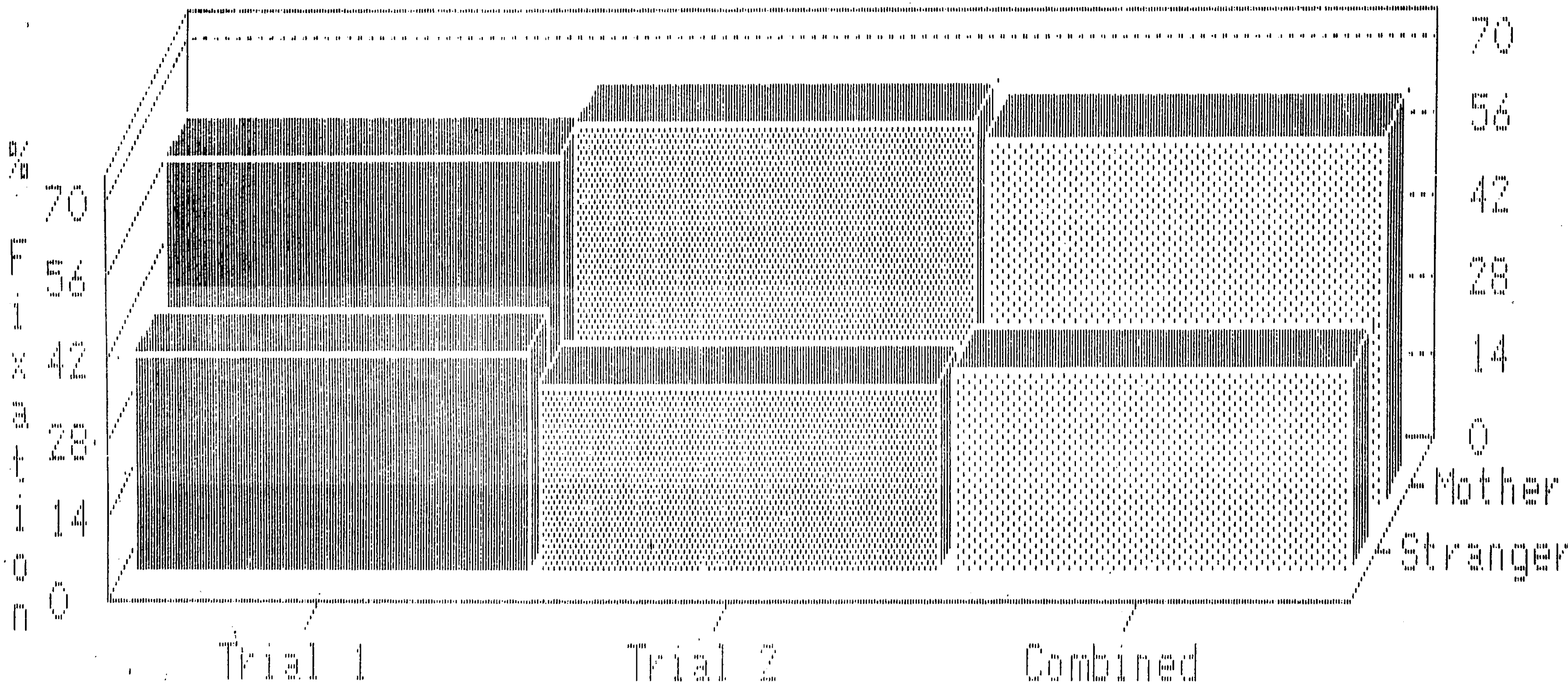


Figure 2.1.3. Percentage preference for the mother and the stranger

To examine whether there was an overall preference for the mother's face on the test trials, matched-pairs _t_-tests were computed for Trial 1 (T1), Trial 2 (2) and for both Trials combined (TB). A preference for the mother's face was predicted as Field et al. (1984) previously reported early face discrimination in neonates, demonstrating a preference for mother over stranger. There was indeed a significant preference for the mother's face on Trial 1 ($t=-2.01$, df=19, $p<0.025$, one-tailed), on Trial 2 ($t=-2.46$, df=19, $p<0.025$, one-tailed) and on the combined trials ($t=2.68$, df=19, $p<0.01$, one-tailed). The one-tailed _t_ values listed in Table 2.1.3 represent the reliability of the difference between stranger and mother preferences. Inspection of the means revealed that neonates' fixated their mother's face (M=62%) more than the stranger's (M=38%) on Trial 1. Similarly, the mother's face received longer looking time (M=68.9%) than the stranger's (M=31.1%) on Trial 2. The mother's face was also preferred (M=64.4%) to that of the stranger's (M=35.6%) on the combined Trials.

Table 2.1.3 One-tailed tests for differential total fixation times for the mother and stranger on Trial1, Trial2 and on the combined Trials

	DF	t	P. value
Trial 1	19	- 2.01*	$p<0.025$
Trial 2	19	- 2.46*	$p<0.025$
Combined trials	19	2.68**	$p<0.01$

* $p<0.025$

** $p<0.01$

<u>Sex differences in preference for the mother's face</u>

A two-way analysis of variance considering one between subjects variable - Sex (Male and Female) and one within subjects variable - Trials (Trial 1 and Trial 2) was performed to examine any sex difference in preference for the mother's face across trials. The scores for the analyses were the percentage fixation to the mother's face The main effect of sex ($F(1, 18)=6.76$, $p<0.01$) was significant, with male neonates demonstrating stronger preferences (M=76.7%) than did females (M=52.2%). However, neither the other main factor, trials ($F(1,18)=0.50$, NS) nor the interaction, Sex x Trial ($F(1, 18)=1.83$, NS) approached statistical significance. The mean percentage preferences for the mother across trials are set out in Table 2.1.4 where it can be seen that while males tended to look at their mother's face more on Trial 2 (M=83.8%), females preferred their mother's face less (M=50%). The overall means indicated that neonates fixated their mother's face almost equally across trials (Mean Trial 1=62%) and Mean Trial 2=66.9%).

The Annova summary table appears in Table 2.1.5.

Table 2.1.4 Mean percentage fixation times to the mother's face across Sex (Male and Female) and Trials (Trial1 and Trial2)

	Mean	Mean	Average
Males	69.6	83.8	76.7
Females	54.4	50	52.2
Average	62	66.9	

N=20

Table 2.1.5 Two-way analysis of variance for Sex effect across Trials for newborn subjects

Source	Sum of Squares	DF	Mean Square	F ratio	P.Value
Sex	5997.6013	1	5997.6013	6.76	0.016348
Sex x Subj. Error	15949.5691	18	886.0872		
Trials	239.1213	1	239.1213	0.50	NS
Sex x Trials	862.1119	1	862.1119	1.8315	0.188944
Sex x Trials x Subj. Error	8472.7543	18	470.7086		

* p<0.01

Stranger effect

To examine whether there was any effect of the stranger used on the preference for the mother's face, a between-groups t-test was computed. Only 18 subjects were included in the analysis as 2 infants were shown a third face. Preference for the mother's face (t=2.01, df=18, NS) just failed to reach significance. Infants who were presented with the face of Stranger 1 (M=74.7%) demonstrated slightly stronger preferences for their mother's face than those who were shown the face of Stranger 2 (M=52.6%). Tables 2.1.6 and 2.1.7 illustrate this difference.

Table 2.1.6 Mean percentage preference for the mother for neonates who were presented with the face of Stranger1 and those who were shown the face of Stranger2

	Mother VS Stranger 1	Mother VS Stranger 2
Mean	74.7	52.6
Standard deviation	15.90	28.77
Variance	253.10	827.99
Sum of Squares	52218.76	31496.43
Standard Error	5.30	9.59
N=18	n=9	n=9

Table 2.1.7 Two-tailed test for stranger effect on preference for the mother's face.

DF	t	P. Value
16	2.01	NS

Age and sex effects on face discrimination

A Sex (Male and Female) x Age (<36 hrs and >36 hrs) analysis of variance was performed on the percentage preference for the mother's face data. Once again sex was included as a factor to examine whether older males and females showed stronger preferences than younger ones or vice versa. The means percentage fixations to the mother's face are shown in table 2.1.8. Though older neonates (>36 hours) demonstrated a slightly stronger preference for the mother (M=69.9%) than did younger neonates (<36 hours) (M=58.9%), the Age effect failed to reach significance ($F(1,16)=3.64$, NS). Older males (M=78.7%) and youger males (M=75.3%) demonstrated almost equal preferences for the mother. The difference in fixation times was between younger (M=34.2%) and older females (M=64.1%). However, male infants less than 36 hours of age showed greater looking time to the mother's face (M=75.3%) than did females of the same age (M=34.2%) and older males (M=78.7%) showed a greater preference for their mother than did older females (M=64.1%) but the analysis revealed a non-significant interaction of Sex x Age ($F(1, 16)=2.33$, NS). Table 2.1.9 presents the ANOVA summary table.

Table 2.1.8 Mean percentage preference for the mother's face across Sex (Male and Female) and Age group (less than 36 hrs and older than 36hrs

		Age group		
		< 36 hrs	> 36 hrs	average
	Males	75.3	78.7	76.7
Sex		n=6	n=4	
	Females	34.2	64.1	52.2
		n=4	n=6	
Average		58.9	69.9	

Table 2.1.9 Percentage preference for the mother's face across Sex (Male and Female) and Age group (<36 hrs and >36 hrs)

Source	Sum of Squares	DF	Mean Squares	F ratio	P.Value
Sex	3710.299	1	3710.299	10.231*	$p<0.01$
Age	1323.086	1	1323.086	3.648	NS
Sex x Age	846.201	1	846.201	2.333	NS
Sex x Age x Subj. Error	5802.24	16	362.64		

N=20 * $p<0.01$

The relationship between the infant's age and extent eof preference for the mother's face

The relationship between age of the neonate at the time of testing and extent of preference for the mother's face was examined further using Pearson product moment correlation coefficients. Though positive, the relationship between age and extent of preference for the mother's face was not significant ($r=0.27$, $df=18$, NS).

The relationship between the infant's birth weight and extent of preference for the mother's face

A further Pearson product moment correlation was performed to examine the relationship between birth weight at testing and extent of preference for the mother's face. The positive correlation obtained was not significant ($r=0.17$, $df=18$, NS).

Number of fixations across faces

To investigate whether infants fixated the two stimulus faces for the same number of times across the two trials, two-way analysis of variance was computed with one between subjects variable, Sex (Male and Female) and one within subjects variable, Trial (Trial 1 and Trial 2). Table

2.1.10 presents the means. The ANOVA summary table (2.1.11) conclusively demonstrates no difference between male and female neonates in the number of fixations for the faces ($F(1,18)=0.69$, NS). The Trials effect just failed to reach significance ($F(1,18)=3.59$, NS), though, subjects' number of fixations on the faces on Trial 1 ($M=5.1$) was larger than on Trial 2 ($M=3.7$). The interaction of Sex with Trials was not significant ($F(1,18)=0.39$, NS). The tendency to look toward the faces was almost the same across Trial 1 and Trial 2 for both females (4.5, 3.6) and males (5.6 to 3.8).

Table 2.1.10 Mean number of fixation for the mother and stranger faces across Sex and Trials Trials

	Trial 1 (%)	Trial 2 (%)	
	Mean	Mean	Average
Males	5.6	3.8	4.7
Females	4.5	3.6	4.1
Average	5.1	3.7	

Table 2.1.11 Two-way analysis of variance for number of fixations for the mother and stranger faces across Sex (male and Female) and Trials (Trial1 and Trial2)

Source	Sum of Squares	DF	Mean Square	F ratio	P.value
Sex	4.2250	1	4.2250	0.6936	NS
Sex x Subj. Error	109.65	18	6.0917		
Trials	18.2250	1	18.2250	3.5951	0.069464
Sex x Trials	2.0250	1	2.0250	0.3995	NS
Sex x Trials x Subj. Error	91.25	18	5.0694		

<u>Number of changes in fixations between the stimulus faces</u>

Number of changes in fixations between the two faces refers to the number of times in a trial that the infant looked away from one face and then turned to look at the other face. It is a measure of the infant's sampling rate of both faces in any given trial.

A two-way analysis of variance was performed with one between subjects variable - Sex (Male and Female) and one within subjects variable - Trials (Trial 1 and Trial 2). None of the variables attained significance, suggesting that there was no difference in number of changes in fixations between the faces across Trials (F(1, 18)=1.81, NS), nor was there a Sex effect (F(1, 18)=0.69, NS). This analysis also produced no significant interaction between Trials and Sex (F(1, 18)=0.55, NS). These data are set out in Tables 2.1.12 and 2.1.13. Inspection of the means indicated that the visual pattern for both male and female neonates was almost the same across trials.

Table 2.1.12 Mean number of changes in fixation between the two stimulus faces across Sex (Male and Female) and Trials (trial1 and Trial2)

	Trials		
	Trial 1	Trial 2	Average
Males	3.6	2.2	2.9
Females	2.5	2.1	2.3
Average	3.1	2.1	

N = 20

Table 2.1.13 Two-way analysis of variance: neonates' number of changes in fixations between the mother and stranger faces across Sex and Trials

Source	Sum of Squares	DF	Mean Square	F ratio	P. value
Sex	3.60	1	3.60	0.6968	NS
Sex x Subj. Error	93	18	5.1667		
Trials (1&2)	8.10	1	8.10	1.8134	0.191108
Sex x Trials	2.50	1	2.50	0.5597	NS
Sex x Trials x Subj. Error	80.40	18	4.4667		

N=20

Discussion

Two findings emerged from the present study. First, mother face recognition is possible within the first 3 days of life. Neonates were not only able to identify the live face of their mother but also to discriminate it from that of a non-parturient, non-lactating female stranger even when the relative hair colour and brightness of the faces varied non systematically across subjects. This result confirms Field et al.'s (1984) finding that infants at ages ranging from 22 to 93 hours could differentiate between the smiling faces of their mother and that of a female stranger.

Second, male neonates showed stronger preferences for their mother's face than did females. This result contradicted that of Field et al.'s. These results will be discussed in further detail in subsequent sections.

Thus, the question -whether mother face discrimination is possible within the first few hours of birth- posed at the beginning of this study was answered. Neonates at ages ranging from 12 to 108 hours fixated longer their mother face. Further younger infants (<36 hours) are no less able than older infants (>36 hours) as revealed by analyses of the data. Their preference for the mother face does not seem to significantly increase with age as one might expect. The most surprising finding is that most of the male babies (6 out of 10) who demonstrated preference for the mother face were 1 day-old. One interpretation is that a floor effect has been measured. A one day-old baby does not seem to differ from a 3 day-old. The range tested was not sufficient for such a comparison. However this result does indicate that preference for the mother is developed in the first day of life and whatever information is used for recognizing their mother, it is utilised from the first day of life. Further research is required to investigate the age effect on face recognition in the first 3 days of life using a bigger sample

The neonates may learn some visual aspects of the mother face as a result of continuous interaction between the mother and the baby. The subjects were retained on the ward at all times in bassinets located at the foot of their mother's bed. They were under the care and responsibility of their mothers. In Field et al.,'s study infants were under the total care of the nursing staff in Hospital and had spent only an average of 4 discontinuous hours with their mothers previous to testing. They were usually taken to their mothers' rooms for approximately one hour for each feed. Whether there is actually, a relationship between the total contact hours involved between the mother and her newborn baby and the extent of preference for the mother's face is still not known. As yet, no systematic attempt has been made to assess the real time exposure to the mother's face.

A study is required to determine the total awake time spent in face-to-face interaction with the mother. In any case such a study would help in the interpretation of the finding of the non-significant relationship between age and extent of preference. The most surprising result is the existence of a preference for the mother's face in babies who are only 12 hours old. The amount of face-to-face interaction with the mother these newborns had experienced is not known, but for some it is certainly less than 12 hours.

Preference for the mother face seems to develop within the first day after birth, if not within the first hour of life. The information the neonate uses to discriminate the mother face is still not known. The slightly stronger preferences for the mother's face (though not significant) demonstrated by infants who were presented with the face of stranger 1 than by those who were shown the face of stranger 2 (see stimuli in the methods section for details about the physical characteristics of strangers 1 and 2) indicates perhaps that neonates may be using more visual information and can learn some visual aspects of their mother's face within the first hours after birth as suggested by Field et al.'s. If this is the case it implies that the visual capacities sufficient for visual discrimination are present and functioning in the neonatal period.

The fact that recognition of the mother's face occurred with mother showing neutral rather than smiling expressions as in Field et al.'s study also indicates that newborns learn some static aspects of the face. Similarly, the neonates' capacity to discriminate their mother face even when auditory information is unvailable suggests first the importance of visual cues in early face discrimination. Second, it rules out the hypothesis that voice cues are necessary for face discrimination to occur (Carpenter, 1974). The possibility however, still remains that the newborn infant draws an association between the already learned voice of the mother and her face during the first contacts following birth. This is made more interesting especially by evidence indicating that infants respond differentially to their mother's voice (DeCasper & Fifer, 1980), and that simultaneous presentation of mother's voice enhances mother's face dicrimination (Masi & Scott, 1983).

Since the present experiment did not control extraneous olfactory information there is a possibility that neonate infants may have discriminated the face of their mother on the basis of olfactory cues especially when tested at a close distance of 30 cm. Evidence suggests that 8-day-olds orient preferentially toward a pad impregnated with their mother's breast milk than to a pad impregnated with a strange mother's breast milk (Macfarlane, 1975). This preference was reported by Schaal et al. (1980) from 4 days of age and by Russell (1976) from 2 weeks of age. Even the odour of the axillary region of the mother was preferred by Cernoch & Porter's (1985) 2 week-old-breast-feeding subjects. These studies will be discused at length in the next chapter.
Also, Carpenter (1974) and Field et al. (1984) using live faces suggested that infants are capable of visual recognition in the first days of life did not control olfactory and auditory cues. Accordingly, the question regarding which information neonates use to recognize their mother, whether is it visual or olfactory or both

cannot be answered at this stage. As mentioned earlier, audition was not involved in this research.

The finding of a significant sex difference with male newborns showing stronger preference for the mother's face than did females is adding more confusion to the literature on sex differences. While it is in accord with some findings suggesting more rapid habituation by male infants (Pancratz & Cohen, 1970; Cohen, Gelber & Lazar, 1971), it is not consistent with Field et al.'s (1984) results suggesting greater fixations to the mother's face by females. The finding that males showed slightly stronger preference for the mother than did females perhaps suggests that females showed a novelty effect after the establishment of the familiarity preference; and therefore, females might be better discriminators of their mothers' face in the first few hours after birth. Actually in the second trial females' fixations increased indicating perhaps a dishabituation for the novel face. This proposition is in part supported by the finding that most of the male subjects were younger than the females. This also suggests the importance of the total amount of exposure to the mother's face prior to testing. A study of a larger sample would be required to clarify this point.

The present study seems to suggest that mother face preference is not influenced by the weight of the infant.

There was no tendency for greater sensitivity to the mother's face on the part of heavier babies. Tiny neonates were no less capable of discriminating their mother's face. This is perhaps due to the fact that very low birth weight infants were initially discarded from the study. Though, the birth weight of the neonate appears not important in early face recognition, evidence suggests that significant impairement in I.Q occurs only among children with extremely low birth weight, that is under 3.5 pounds (Koop, 1983). A significant relationship between high intelligence and high birth weight in the first 3 years of life was found by Moore, Bushnell and Goldberg (1987).

The non-significant difference between the two Trials in number of fixations for the stimulus face indicated that overall, babies did look at both faces. This supports the finding of preference for the mother demonstrated by neonates on both Trials. From the start they were aware of both faces and attended to them systematically. The fact that males and females did not differ significantly in their number of fixations suggests a similarity between the two sexes in their discrimination processes. The difference may be lies in the length of fixations rather than in the number of fixations.

Also no difference was found between neonates in number of changes in fixations between the two faces across the two trials. Nor was there a difference between males and females in number of turns toward the faces. Overall the neonates sampled the faces three times without looking away, turning their fixations from the face of the stranger to the face of the mother. The on-off alternations suggest not only the presence of such visual processing but also its rapidity. The finding that newly born infant's visual processing was not influenced by sex indicates no basic difference between the two sexes in sampling the two faces but in the length of the visual fixation after they turned to the mother.

Conclusion

Field et al.'s finding of very early face discrimination was confirmed, using a spontaneous visual preference technique and paired presentation of the comparison faces. Neonates a few hours after birth recognized the expressionless face of their mother. The differentiation between two faces of different categories (familiar vs novel) in the present procedures suggests that as young as a few hours, the neonates are basing their discrimination on previous experience with the familiar face. This study provides support for the suggestion that the newborn infant may learn some visual aspects of the mother's face, as slightly stronger preference for the mother's face (though not significant) was demonstrated by neonates whose mother's face was paired with a female stranger differing considerably from the mother in terms of hair length and colour and brightness of the face. Further research involving larger samples, one female stranger for each subject and a control over olfactory information and brightness of the faces would be required before firm conclusions could be reached on which information the neonate uses in the discrimination process and whether male neonates actually prefer their mother's face more than females .

The procedure employed in this first study provided a clear result, a finding which suggests that it may be a suitable method for use in a more extended study of face discrimination.

Chapter 3

REVIEW OF THE LITERATURE ON OLFACTORY DISCRIMINATION BY NEWBORN INFANTS

Introduction

This chapter is a review of studies of olfactory perception in the human neonate. Can the newborn infant discriminate between his own mother and a female stranger on the basis of olfactory information? Can he use smell to locate his own mother's position ?

To answer these questions, one may first need to find out whether the newborn infant actually perceives odours. What is the earliest age at which olfactory discrimination of any kind is possible? Does the newborn baby's perception of olfactory stimuli change over time?

The data demonstrating the neonate's ability to perceive and differentiate between olfactory stimuli come from different sources: 1) Studies examining the neonates' responses to artificial odorants and from 2) Studies exploring neonates' responses to human biological odours. The latter involve amongst others the discrimination of the biological odours of the mother and olfactory cues associated with parturation and lactation.

Several substantive issues are discussed, such as to what extent the neonate responds to olfactory stimuli, how the responses change with repetitive stimulation and sex differences in olfactory preference. The last section discusses methodological issues.

First, it was felt necessary to know what olfactory acuity means in general.

1.1 Olfactory acuity

Most reports on olfaction suggest that compared with vision and audition, the sense of smell is less important for human beings. This comparison is usually followed by another in which the sense of smell of the human is held to be less sensitive than that of many other animals.

In absolute terms, the human sense of smell is quite sensitive. While bettered by other species, in some people it may be a very effective chemical detector (Wright, 1966). Its threshold of perception is more than one hundred times lower than the best gas chromatograph. For example, usually an adult can detect the rotten egg odour of hydrogen sulphide, the garlic odour of thiocresol, or the skunk odour of ethjl mercaptan if 10, 1 or 0.5 ml, respectively, of the substances are dispersed in 10,000 litres of air. An adult would detect one small drop of perfume diffused into the entire volume of six rooms (Galenter, 1962); although this drop of perfume would contain an enormous number of molecules to be detected.

Thresholds of olfactory sensation indicate that smell is evoked by about 1/60,000 of the concentration required to produce a cutaneous or burning sensation (Geldard, 1972, p.439). Methods are available for determining the threshold of odorous substances in adults. In the case of the strongest odorants, however, the amount that has to be released in order to be just detected by the nostrils, is very small. The threshold can be determined by evaporating the concentration of the odorous substance into a known volume of air; next by mixing it with equal parts of air to produce progressive dilutions of 1.5, 1,25, etc., until the point where odour sensation fails to be elicited.

Although thresholds appear to be the most basic psychophysical measures of perception, there have been few studies to present realistic estimates of these fundamental properties in neonates. In fact, the recent sensory data on olfaction in newborn infants have primarly rested with findings from Engen, Lipsitt and Kaye, 1963; Lipsitt, Engen and Kaye, 1963 and Engen and Lipsitt, 1965. In Lipsitt et al.'s (1963) study, olfactory thresholds, measured in terms of the concentration of a solution of asafetida in diethlphthalate required to produce a response, decreased steadily during the first 4 days after delivery. The fact that newborn infants responded to olfactory stimuli and in different degrees to acetic acid, asafoetida, phenylethyl alcohol and anise oil demonstrates that the human infant is sensitive to olfactory stimulation shortly after birth.

The findings of Lipsitt and his colleagues are of considerable biological interest as they show a rapid increase in the sensitivity of the olfactory system during the first few days of the infant's life. It should be noted, however that in this study the threshold measurements are relative to one state only: regular sleep; accordingly, the results cannot be explained by variability in the neonate's state on successive days. This fact enables one to limit the number of interpretations. In addition, Lipsitt et al.'s work is highly informative; the relevant environmental conditions reported, together with precise descriptions of the neonate's state at the time of olfactory stimulation being well specified. States here are "(... **defined as finite and discrete vectors representing distinct and qualitatively different conditions, each of them considered as particular modes of nervous activity"** Prechtl, 1974; p.185).

Unfortunately, there is a lack of reference against which one can judge such data and draw comparison with other olfactory acuity data. As Engen (1982) pointed out, the information about olfaction is always anecdotal. Yet there are no measures of olfactory sensitivity similar to oscilloscope for example which can produce pictures of sound waves, as for hearing.

Before discussing recent work on olfactory perception in newborn infants, it may be useful to briefly summarize early reports on the subject matter.

1.2 Summary of early studies of olfactory perception in the human neonate

There is a lack of data concerning the newborn's capacity to detect smells and to discriminate amongst olfactory stimuli, for virtually very little research on this topic has been carried out. Until about 50 years ago, there had been a few systematic studies, but with ambiguous findings (see Disher, 1934; Pratt, 1954 for reviews). Infants were found to respond only to such stimuli as acetic acid and ammonia, but it was held that these responses were largely the result of pain or irritation (stimulation of the trigeminal nerve) rather than smell (stimulation of the olfactory nerve). Some researchers reported infants' responses to so-called pure odour stimuli, e.g., mint, valerian and essence of lavender, but others failed to verify this finding. Also, while some reports suggested that newborn infants are able to differentiate between pleasant and unpleasant odorous, others argued that olfactory sensitivity is not present or is poorly developed at birth.

As early as 1859 Kussmaul (see Engen & Lipsitt, 1965) found 1-month premature infants able to discriminate between olfactory stimuli. They responded to asafetida and certain other odours, but not to irritating substances. In addition he observed decrement in response to repeated presentation of olfactory stimuli in the newborn. He was, however, not sure that similar responses occurred in earlier premature infants.

Carmichael (1970) cited a number of writers including Darwin (1877) who have provided anecdotal reports that infants may use olfaction to identify their mothers at an early age. Preyer (1882) reported that an 18 day-old infant refused a breast nipple on which kerosene had been placed but eagerly accepted the other "kerosene free" breast shortly after refusal. Pratt, Nelson and Sun (1930) reported that Preyer, Canestrini Peterson and Rainey in separate experiments observed smell reactions in premature infants and obtained preliminary but conflicting evidence that infants may be attracted to the odour of their mother's milk when nursing. Disher (1934) appears to have been the only researcher to use different intensities of odorants in the study of neonatal response. In one study, she examined newborns from the age of 3 hours to 10 days. She obtained an increasing percentage of response from 51% to 71%, to four intensities of stimulus. In addition, Disher found no age differences in olfactory response in the first four days and supposed that there would be none within the first 10 days. Similarly, Pratt, Nelson and Sun (1930) found no age differences in the percentage of response to various ungraded odours between birth and four days of age, and even up to 11 days. More recently, Bronstein, Antonova, Kamenetskaya, Luppova and Sytova (1954) used suppression of sucking as an indicator of smelling and hearing in neonate infants. They placed a pacifier in the infant's mouth and during sucking, they presented an odour or a tone. The introduction of an odour to a sucking infant will initially disrupt sucking behaviour and this "suppression" will habituate with repetition of the same odour. But the weaker the odour, the more effective and rapid the adaptation was. Again no age differences in reactivity or cessation of reactivity to odorants were found.

To answer the questions set in the introduction, it was seen to be appropriate to review firstly studies of neonates' responses to artificial odorants as these studies present evidence on an infant's ability to perceive and discriminate odours shortly after birth. Neonates's responses to the mother's biological odours will then be discussed. Both categories of research provide information about the earliest age at which odour perception is possible and whether the neonate's perception of olfactory stimuli changes over time.

1.3 Neonates' responses to artificial odorants

The earliest study by Engen and Lipsitt and Kaye (1963) dealt with the neonate's responses to odours. They compared the responses to acetic acid to phenylethyl alcohol and to anise oil to asafetida. The 20 newborn infants used were on average 50 hours old and were asleep when tested. This state was chosen because Lipsitt & Levy (1959) found that thresholds are higher when the baby is asleep. The odour was presented for 10 trials via a Q-tip saturated with the solution. The duration of the stimulation was 10 seconds and the time between each trial 1 minute. The responses recorded were respiration, heart rate, leg withdrawal and general movement. The 10 seconds prior to each odour presentation were utilised as a baseline to assess the occurrence of the response (based on the judgments of three observers who agreed on 86% of the trials). On average, neonates responded more strongly to acetic acid than to anise oil. According to adults acetic acid would be classified as irritating or painful whereas anise oil would be termed pleasant. For Engen et al., the values obtained may reflect differences in intensity of the odours. Further, a decrement in response to repeated stimulation made by one pleasant (anise oil) and another unpleasant (acetic acid) stimulus and a recovery after a temporal delay were found across trials. Whether it was a sensory adaptation (changes in receptor organs produced by repeated stimulation) or a response habituation (extinction of a response to an originally novel or intense stimulus) was difficult for Lipsitt et al. to answer. They referred however to Bronshtein et al.'s (1958) study which suggested sensory adaptation.

Though this study demonstrated that neonates can smell soon after birth and found changes in thresholds it did not control intensity of odours presented to infants and did not counterbalance the order of presentation of the stimuli.

Lipsitt, Engen and Kaye (1963) next studied the developmental changes in odour perception with increasing age over the first days of life. They measured the olfactory thresholds of 10 newborn infants at an average age of 16 hours and then every 24 hours for the next 4 days. The method of presentation of the olfactory stimuli and recording of the results was the same as in Engen, Lipsitt and Kaye (1963). The stimuli used were (anise and asafoetida) in graded intensities from 1.6125% to 100%. The dilutant utilised was diethylphythalate which is odourless. Each infant was presented with the weakest solution first, then with increasing intensities until the neonate's threshold had been obtained for that day. Lipsitt et al.'s results showed that **"...the olfactory thresholds change drastically within the first few days of life"(p.376).** Neonates showed an increased sensitivity to olfactory stimuli over the first few days of life.

In addition, re-presentation of the original odour produced a slight recovery effect. Lipsitt, Engen and Kaye concluded that their results resemble findings in other sensory dimensions and suggested that olfaction may be used as a possible measure of individual difference, though they did not provide any individual data. Lipsitt et al.'s study demonstrating changes in olfactory thresholds with age in the neonate effectively controlled extraneous stimulating cicumstances such as temperature, humidity and noise, which other studies did not and which probably led to their finding no age effect on olfactory threshold.

In another study, Engen and Lipsitt (1965) examined the decrement and recovery of responses to olfactory stimuli in newborn infants. The methods of recording and measuring infants' responses were the same as in Engen, Lipsitt and Kaye (1963). Seventy neonates were tested, with an average age of 55 hours. In the first part of the study, 10 infants were given a 50% -50% mixture of anise oil and asafetida. Half of the subject group was tested with a 50% anise oil solution (diluted with diethylphthalate) on the next two trials. The other half of the group was tested with a 50% asafetida solution. Further, while 10 naive infants were tested with asafetida solution, another 10 were given a 50% solution of anise oil to habituate the infants to each odour.

Neonate infants demonstrated that olfactory sensitivity is present soon after birth but is subjected to changes with increasing age and repeated stimulation. There was a decrement in response over time to the anise-asafetida mixture and a recovery to asafetida, but not to the anise oil.

In the second part of the experiment, amyl acetate and heptanal were used to obtain a mixture of 33% amyl acetate and 17% heptanal and 50% dilutent. The two groups of infants received 10 trials with this mixture. There were approximately equal intensity odours in those proportions, according to adults' judgements. The same procedure was adopted for the amyl acetate-heptanal solution as for the anise oil-asafetida solution. In the posttest one group was tested with 33% amyl acetate and the other with 17% heptanal. Again, a decrement in responses to the mixture was found over the 10 trials. For Engen and Lipsitt, this decrement supported a habituation hypothesis rather than sensory fatigue proposition.

These three studies demonstrate the ability of the newborn to perceive and differentiate between olfactory stimuli. Further, it appears that newborns' olfactory thresholds change with increasing age and repeated stimulation. However, these studies raise several methodological questions. For instance, the use of "irritant" substances as olfactory stimuli may have stimulated both the olfactory nerve and the trigeminal nerve.

Therefore, the newborn response may not have been caused by smelling an odorant, but rather have been due to a physical reaction to general irritation. The presentation of the stimulus was at a closer distance (5mm away from the subject's nostrils). The distance factor is very important in olfactory discrimination. At closer distance the odour is stronger and it is more likely to be detected. Also, the newborns -as in most studies of olfactory perception, -were tested when sleeping so the importance of the state variability should have been lessened, but, absolute sensitivity to the odours was possibly severely reduced compared with an alert, attentive state.

Rovee (1969) used the same method and response measure as Lipsitt et al. (1963) to determine the olfactory response to aliphatic alcohols in infants ranging in age from 30 to 107 hours. The olfactory stimuli (propanol, pentanol, hexanol, octanol and decanol) were presented by placing the saturated cotton tip at about 5mm beneath the subject's nostrils. The relationship between response magnitude and intensity was approximately linear. These results are consistent with adult scaling data reported by Engen (1965) and Engen et al (1968), but the neonate's slope values were higher than those obtained by Engen (1968) from adults.

In a second part of Rovee's study, 10 neonates with a mean age of 62 hours were tested on 11 concentrations of each alcohol. The threshold of a subject was defined as that concentration to which the infant first responded. Average threshold concentration was found to be a decreasing function of the number of carbons in the alcohol chain as reported by Engen (1965) who obtained higher values over all concentrations. Rovee's data demonstrate that the newborn has a much keener olfactory sense, capable of making finer discriminations than previously believed.

In an attempt to control some of the factors which might have influenced the data obtained by Engen et al. (1963), Lipsitt et al. (1963), Engen and Lipsitt (1965) and Rovee (1969), Self, Harowitz and Paden (1972) carried out an experiment in which they used 1) only purely olfactory odours. 2) more than one response measure. Thirty two subjects were examined. Eight of them were tested on three consecutive days, at 24 hrs of age, 48 hrs and 72 hrs. The other 24 subjects were divided into 3 groups of 8 infants and called cross-sectional group of infants. The first group was tested at 24 hrs, the second at 48 hrs and the third at 72 hrs after birth. Each infant was presented with 4 odours (oil of anise, tincture of asafetida, oil of lavender, and tincture of valerian) and the wet control (water of tap). Presentation of stimulus was made by Q-tip, the end of which was saturated with the liquid . The odorant was held at 5mm from the infant's nostrils. Response measures were respiratory changes and observational data. The respirometer data of the logitudinal group indicated that by Day 3 neonates responded to three odours (asafetida, tincture of valerian and oil of lavender). The cross-sectional group of infants, in contrast, did not significantly respond with a high frequency to any odour on the same day. The visual judgment data showed that the longitudinal group did not respond in large numbers to any of the odours on any day; while the cross-sectional group did respond to asafetida and valerian on Day 3, as well as to asafetida on Day 1. Both males and females of this group gave more responses to the odours than did the longitudinal males and females. In the combined data, the infants did seem to be comparable on Day 3.

The above finding seems to be consistent with the suggestion that the **"...infant organism is inherently variable and that only as a history is accumulated does there develop a base of stability" (Horowitz, 1969, p.113).** Further sensitivity to the wet control which was first presented decreased over days. For Self et al., this is the complement of the habituation effect reported by other researchers.

These data again indicate that neonate infants are able to perceive and differentiate between odours. Their olfactory threshold changed over the first three days. At this age some infants showed even lengthier retention. They responded to an odour even when it was presented first. Further the newborn's olfactory sense not only reflects the interindividual variation but is also a result of the intraindividual variability in responding.

Steiner (1974) photographed the facial reactions of 175 newborns to different tastes and smells confirm the finding that neonates can discriminate between odours. The stimuli used were a diluted artificial butter flavour as the next best representative of 'milky" odours; vanilla and banana extracts, sampled "fruity" odours and artificial schrimp flavour, "fishy" in its odour character, and an artificial flavour of rotten eggs, presented as representatives of "bad" or "aversive" food-related odours. Propylene-glycol was used as a diluent of the odorous substances. All babies of 12 hours of age displayed facial reactions to odour stimuli. The odour of vanilla seemed to elicit pleasure and the "fishy" odour of artificial schrimp flavour appeared aversive according to the observers judging the photographs.

Though this study indicates the neonates' capacity to discriminate between different odours, one might argue against the use of photographs for judging the facial expressions of the infants as photographs lack much information which a live face would contain. Also

Steiner did not provide details on the method he used, or how the olfactory stimuli were presented to the subjects

In one study by Reiser, Yonas and Wikner (1976) infants from 16 to 130 hours turned away from the odour source more often than they turned toward it. The newborns were presented for 3 sec with two cotton swabs: one contained a small drop of ammonium hydroxide, the other was sterile. The odour source was placed at 5 mm from the nose slightly to the left or right of midline. Reiser et al.'s result is not consistent with Bower's (1974) proposition that newborns turn to the left when the odour is presented to the right of body midline and to the right when it is presented to the left which indicates that the location of the odour is being detected. In addition, newborns demonstrated a right bias in the direction of the head movements. For Rieser et al. the finding that when the infants did not turn away from the odour they preferred the right side, is in accord with the results of studies describing asymmetrical response in neonates. Turkewitz, Gordon and Birch (1965) found that neonates tend to turn to the right in response to a tactual rooting stimulus. Also, a bias for right eye movements was demonstrated by newborns in response to sound. Turkewitz et al. (1966) and Wada, Clarke and Hamm (1975) suggested that the asymmetrical responses showed by newborns may have an anatomical correlate. They observed that in most neonates, the left temporal lobe is larger and more differentiated than the right. Reiser et al. then concluded that the newborn is innately sensitive to the radial location of an odour. **"A mechanism for detecting the location of an aversive odor is functioning only hours after birth"(Reiser, Yonas and Wikner, 1976, p.859).** However, the degree to which the olfactory and trigeminal nerves contribute to this spatial sensitivity is still not known.

Infants turned away from ammonia, another trigeminal stimulus, but they might turn away from a pure odour that does not stimulate the trigeminal nerve, particularly if it is strong. Experiments separating odour intensity and quality and stimulation of olfactory nerves as opposed to trigeminal nerves cannot be carried out on human subjects.

In an attempt to identify the clinical responses of the sleeping neonates to olfactory stimuli, Sarnat (1978) tested 68 full term infants, 15 premature of 32 to 36 weeks' gestation, 11 preterm infants of 29 to 32 weeks' gestation and 6 infants of 28 weeks'gestation or less within the first three days after birth for 2 days. A small glass tube containing cotton soaked with 0.5 ml of peppermint extract was used to evoke responses. A second tube with dry cotton, serving as a control, was presented before the testing. The tube was held 1cm beneath the infant's nostrils. The subjects were tested while sleeping. All neonates of more than 32 weeks'gestation responded to the olfactory stimulus. Olfactory stimulation evoked more sucking responses than arousal-withdrawal. No differences in responses between preterm and term infants were found. Further, individuals showed different responses on successive days. The decrement of the olfactory response in successive trials was due, according to Sarnat, to habituation rather than sensory fatigue.

This study presents a number of weaknesses. Firstly, it used a method which lacks the refinements of quantitation with graded intensities of the odorants. Secondly, the data obtained were based on judgments made from the clinical observations of a single experimenter.

More recently, Balogh and Porter (1986) continually exposed neonates to Ginger and Cherry odorants within the first day after birth for approximately 24 hours. For each baby one of these odours was termed familiar and the other odour the unfamiliar stimulus. All infants were tested during active sleep -eyes closed, irregular respiration, small movements (state II of Prechtl, 1974)- after 23 to 67 mn following the removal of the odour pads. Only female neonates demonstrated preferential orientation to the exposure odour. Males, however, displayed a right turning bias regardless of odour location. This effect was found by Rieser, Yonas and Wikner (1976), Turkewitz (1977) and Liederman and Coryell (1981). They also seem to suggest that early behavioural asymmetry may be predictive of subsequent handedness (Gesell & Ames, 1947; Coryell & Michel, 1978).

The above study entailed long exposure of the infants to the training odours, which could have been associated with the reinforcers of food and warmth. A larger sample combined with a shorter odour exposure period and intervals between familiarity and testing sessions may elucidate the basis for the observed sex differences. It is unfortunate that Balogh and Porter did not test their subjects before the odour exposure period and during this familiarity session. Such data would reveal how much time is needed for the establishment of olfactory familiarity in both sexes.

Summary

That human newborns do demonstrate differential reactions such as changes in rate of respiration and rate of heart beat, leg-withdrawal, bodily activity to different smells has been shown by Engen, Lipsitt & Kaye, 1963; Lipsitt, Engen & Kaye, 1963; Engen & Lipsitt, 1965; Rovee, 1969 and Self et al., 1972 who also included visual judgements as to the infants' responses. Sucking and arousal-withdrawal responses have been reported by Sarnat, 1978. Even facial grimaces were observed in newborn babies who were presented with odours of artificial food. Head turning response -as indication of discrimination of olfactory stimuli- was displayed only by females in Balogh and Porter's study (1986). Both males and females in Reiser et al.,'s experiment (1976) turned their heads away from ammonia, an aversive odour. They showed on average a right bias in the direction of the head movements. So did Balogh and Porter's (1986) males when exposed to Ginger and Cherry for 24 hours previous to testing. Thus, the newborn infant can perceive and discriminate between odorants shortly after birth. Further he has a decreasing olfactory threshold with increasing age and habituates with repeated presentations of a given odour (Engen et al., 1963; 1963; 1965 Self et al. 1972 and Sarnat, 1978).

1.4 Neonates' responses to biological odours

Few studies have been concerned with neonates' responses to human biological odours. Most of the work which has been carried out has been designed to test whether babies can distinguish between the smell of their own mother and that of a strange mother within the first days following birth. Findings have shown that, presumably because of the odour, newborn infants turn more often toward a breast odour of their nursing mother.

Macfarlane (1975) studied the possibility that newborn infants can use smell to locate a food source. Infants aged between 2 days and 7 days were presented with one clean pad and one breast pad which had been in contact with the mother's breast for three to four hours. The mothers used no creams on their nipples. At 5 days of age neonates turned more often towards a breast pad that had been worn by their own mother and was presented to one side than towards the clean pad that was presented on the other side.

In a second experiment, Macfarlane tested 32 babies for their ability to discriminate between the smell of their own mother and that of another mother. At 2 days of age the neonate turned to either pad more or less at random. By 6 days of age 22 out of the 32 turned more towards their mother's breast pad ($p<0.02$, bimodal) and at 8-10 days 25 neonates showed such preference ($p<0.001$, bimodal). The average percentage of times the neonates turn toward their own mothers increased from 57.8 to 60.3 and 68.2 % respectively.

Macfarlane's results, demonstrated that from the 4th day infants can respond discriminately to the breast odour of their mother. Further, they can use olfactory information to locate the source of milk of the breast.
It should be pointed out here that since the olfactory stimuli were presented quite near each other, it is not

clear whether the neonate smelt one odour at one time or a combination of the two.

A year later, Russell (1976) showed that young infants are likely to make orienting responses and to begin sucking towards their own mother's breast pad rather than to that of a strange mother's. A group of breast-feeding neonates were presented with 1) a clean moist pad; 2) a familiar (own) mother's pad, and 3) a strange mother's pad. The subjects were tested on the second day, during the second week, and during the sixth week after birth. During the 6-week test the infants were also tested with a pad that had been moistened with raw cow's milk. All infants were tested while sleeping. No details were given about the sleeping state of the infants. The olfactory stimulus was presented under the infant's nose at a distance of 1-2 cm for about 30 sec. At 2 days neonates showed no differential response towards the mother's pad and the strange mother's pad. At 2 weeks of age the infants demonstrated general arousal and minimal discrimination of the mother's odour. At 6 weeks of age infants preferentially oriented toward their own mother's odours and started sucking. This behaviour was markedly different from their response to both the unfamiliar mother's odour and the odour of raw cow's milk. The responses to the raw cow's milk were the same as to the strange mother's pad. For Russell, olfactory maternal attraction suggests that human possess a pheromonal system which operates at a very early age.

More evidence on the neonate's ability to perceive and discriminate the mother's odours soon after birth was obtained by Schaal, Montagner, Hertling, Bolzoni, Moyse and Quichon (1980) who studied the recognition of maternal odours by newborn infants. Each infant was presented with two cotton pads. One of them was impregnated with diverse odours of breast and nipple secretions and odours from the neck and shoulders of the mother, the second was moistened by a strange female's odours or an ordourless pad. The 20 infants were tested on the second, fourth, eighth, tenth and twelfth days. As their results indicated, the infants spent significantly longer oriented toward the pad containing their mother's odours than to the pad with odours of a strange female. This result demonstrates that at 4 days of age infants can recognize odours of their mother. But, contrary to previous studies, in Schaal et al.'s experiment the mother's odour was composed of lactation, sebaceous and sudoripares secretions and artificial odours (perfumes, make-up etc). In any case, whatever the composition of the mother's odour was, it was still the odour characterizing their mother that infants preferred and recognized.

One weakness of this study is that Schaal et al., did not weigh the amount of secretions the pads contained. Different concentrations may yield different sensitivities. Also, not all mothers and strangers wore perfume or the same one. Neither did all of them have make-up or used the same products. Accordingly, the odour of one pad sometimes included perfumes and make-up while the other did not. The one which included perfume sometimes contained alcohol.

Preferential responsiveness to maternal olfactory cues is however not only restricted to odours from the breast, shoulders and neck. Even the axillary odours of the mother can be recognized by her offspring in the first two weeks after birth. A series of investigations dealing with infants' recognition of their parents through axillary odours was conducted by Cernoch and Porter (1985). Two-week-old infants were presented with two odour stimuli (gauze pads). One of the odours was hung to the left and the other to the right side, at 1-2 cm away from the infant's nostrils. One of the gauze pads had been worn in the underarm area of the mother (or father), and a second pad had been worn by the unfamiliar adult for 8 hours during the night preceding testing. The infant's responses to the odours were videotaped throughout the two 1-min trials. Breast-feeding infants oriented preferentially to axillary odours of their mother in comparison to odours produced by either unfamiliar or nonparturient lactating females. However, they failed to recognize the axillary odours of their fathers. In contrast, bottle-feeding infants displayed no evidence of recognizing the odour of their mother when presented with odours from a parturient female or a strange bottle-feeding female.

Cernoch and Porter cited a number of explanations for the differences in responsiveness to maternal axillary odours observed between breast-feeding and bottle-feeding infants. Firstly, breast-feeding infants may be more sensitive to olfactory cues, that is they possess a lower detection threshold than bottle-feeding infants for olfactory stimuli and therefore are more able to recognize their mother's characteristic body odour. Secondly, the difference in odours among lactating mothers might also be greater than that among nonlactating females. Thirdly, the breast-feeding infants are more exposed to body odours produced by their mothers than the bottle-feeding infants are.

<u>Summary</u>

It is clear from the above studies that newborn infants can not only perceive and differentiate between biological odours but can also show preference for their mother's olfactory cues over their father's and the unfamiliar odours of a strange female. Infants ranging from 4 days to 6 weeks respond discriminately to the breast odour of their mother (Macfarlane, 1975; Russell, 1976; Schaal, Montagner, Hertling, Bolzoni, Moyse and Quichon, 1980). Also, 2 week-old, breast-feeding infants orient preferentially to the pad impregnated by their own mother's axillary odours (Cernoch and Porter, 1985). But much earlier, at 4 days of age, breast-feeding infants display a significant preference to a mixture of lactating, sebaceous and sudoripares secretions, and artificial (perfumes and make-up) odours (Schaal et al., 1980). In addition the newborn's sensitivity to biological odours increases over the first period. The differentiation between the mother's odour and that of strangers is not present at two days of age (Macfarlane, 1975; Russell, 1976; Schaal et al., 1980) but develops around the 4th day and became stronger between the 10th and 15th day.

The reliability of the findings that newborn infants are capable of discriminating their mother's odours is indicated by the fact that in all these studies the infants did not see their mother's face, that is visual information was absent, and any differentiation was based solely on olfactory cues.

1.5 Sex differences in olfactory perception

Overall, the studies examining the neonate responses to artificial odours and biological odours of the mother suggest that sex is not a determining factor in olfactory sensitivity and discrimination (Engen et al, 1963; Lipsitt et al., 1963; Engen et al., 1965; Rovee, 1969; Steiner, 1974; Reiser et al, 1976; Sarnat, 1978, Macfarlane, 1975; Russell, 1976; Schaal et al, 1980; Cernoch and Porter, 1985). However, Self, Horowitz & Paden (1972) who studied the infants' ability to perceive and discriminate chemical odours reported that male infants tended to give "cleaner" respirometer recordings than the females (see above for further details). Also, they responded more to asafoetida than to oil of anise, oil of lavender and tincture of valerian. Analyses of the visual judgements, however, did not confirm these results. No sex differences were found. These contradictory findings suggest once more that sex differences are susceptible to fluctuation. They vary not only from one study to another but also within the same experiment when different methods are used. This proposition is in part confirmed by Balogh and Porter's (1986) results (see study above for more details). While female infants demonstrated preferential orientation to the exposure odour, males displayed no evidence of preference for the exposure odour. They, however, showed a right turning bias regardless of odour location. For Balogh and Porter familiarization with an olfactory stimulus within the first day after birth is sufficient for female newborns to develop preference to that odour.

Summary

From the studies reviewed above there is already strong suggestive evidence that sex effect is not systematic. Apparently it varies not only from one study to another but also within the same research if different procedures are used. Further sex differences were found when head turning was adopted as a dependent variable, with male infants showing a right turning bias.

1.6 Meodological Issues

Problems of sampling

One of the problems in all the studies reviewed above is that of constituting samples of infants without taking in to consideration the type and amount of medication their mother had during labour and after birth, especially for breast-feeding infants. It is important in this type of research (a) to study the medical records of the mother and specifically note the type and amount of maternal medication administered since labour until the testing day; (b) to investigate the composition of the drugs and their specific effect on the newborn infant and to discover whether drugs have similar effects and (c) to examine the relationship between olfactory response and the amount of drugs taken by the mother on the testing day.

Response measure

One of the difficulties in reviewing a range of studies and comparing their findings, is that a variety of response measures have been used in the assessment of olfactory perception and discrimination of the maternal odours. These are of varying quality in terms of their validity and reliability. In studies examining the newborn's responses to artificial odorants, investigators have recorded differential reactions: respiration, heart rate, leg withdrawal, general movement (Engen et al., 1963; Lipsitt et al., 1963; Engen & Lipsitt, 1965; Rovee, 1969). Self et al., (1972) have measured respiration of the infant and observed his behaviour. Others have odopted suppression of sucking as an indication of olfaction (Bronshtein et al., 1958) or combined sucking and arousal-withdrawal (Sarnat, 1978). Facial grimaces also have been considered as responses to olfaction (Steiner, 1974). Head-turning was utilised only by Reiser et al. (1976) and Balogh and Porter (1986). However, all studies examining neonates' responses to the biological odours of their mother have employed head-turning as an indication of olfactory discrimination (Macfarlane, 1975; Russell, 1976 and Cernoch and Porter, 1985). Head-turning and arm movements were combined by Schaal et al.(1980).

Thus, results which seem comparable came from studies using different response measures. Most of the studies which measured respiration and bodily movements used irritant stimuli (e.g. Engen et al., 1963, 1963, 1965). It follows that the response may have been a general reaction to irritation, though it proves that the infant had smelt it. Self et al., (1972) who combined two response measures found conflicting results. Thus a finding which is taken as substantial may be proved by another study using a different response measure to be false. Also, the photographing of the infant's facial grimaces to judge whether there was a marked relaxation of the facial muscles resembling smile or depression of the mouth seems not reliable, especially because the facial reaction was judged on a two-dimensional representation, not from a live or at least a filmed representation. The head-turning appears to be inappropriate in discrimination involving artificial odorants. In fact, in both Reiser et al., (1976) and Balogh and Porter's studies (1986) infants showed right bias. The fact that the use of this measure worked well in studies involving the mother's odour suggests that infants did not only discriminate their mother's odour but preferred it to a stranger's odour. The newborn infant may have learned the odour of their mother soon after birth; and the head-turning may have been reinforced from birth in breast-fed infants. Actually, all studies examining the neonates' responses to the biological odours of the mother involved breast-fed babies.

Reliability of observation

The reliability of the observer's recording can also be called into question. Bias, as a result of non-independent judgement or of the use of a single observer may have occurred especially in studies examining infants' responses to artificial odorants. In most of the studies reporting the neonates' preferences for their mothers' odours the interobserver reliability varied between 80 and 90% (Macfarlane, 1975; Cernoch & Porter, 1985). While Schaal et al. (1980) videotaped the behaviour of their subjects and later analyzed the movements of the infants' hands and nose when the maternal odours were presented, Russell (1976) neither used blind scoring nor relied on independent judgments.

Stimulus type

The major problem facing any researcher examining the young infant's ability to discriminate the mother's olfactory cues is that evidence suggests the neonate's capacity to perceive odours and that the olfactory system is functioning shortly after birth comes from studies which used artificial odorants. However studies using the biological odours of the mother have found sensitivity to odours only from 4 days of age. This is the earliest age at which such recognition was reported. This discrepancy in age at which olfactory sensitivity to artificial and maternal odours has been demonstrated may have resulted from the difference in stimulus intensity.

The two categories of stimuli (artificial vs human) possess different physical characteristics and chemical composition, have different threshold concentrations, and lead to different sensitivities.

In some studies the artificial odorants (e.g. Engen et al., 1963; 1963; 1965 and Self et al., 1972) were sometimes composed of a larger portion of alcohol such as tincture of asafoetida and tincture of valerian. Accordingly, these odours are more volatile, mix rapidly with the air and elicit greater response than those which do not contain alcohol. Also, some of the odours are pleasant, others are unpleasant or irritant. The irritants stimulate both the olfactory nerve and the trigeminal nerve. This is another weakness from which these studies suffer. Thus, the responses obtained might not have been caused by the infant's smelling an odorant, but rather may merely have been reactions to a general irritation.

In studies examining infant responses to the biological odours of the mother, the stimuli were always milky odours of breast, bottle or raw cow's milk; or odours of secretions of the body. Apart from Schaal et al.,'s (1980) study in which the mother's odour contained perfume and make-up, in all the remaining studies, the mother's odour neither contained alcohol nor was it an irritant.

Moreover, with the exception of Balogh and Porter's (1986) study in all the research using artificial odours the stimuli were novel. Conversely, in all the studies involving recognition of the mother's odour one of the stimuli was familiar and the other novel. The data thus present a familiarity vs novelty effect, such as in Balogh and Porter's.

State factor

The state of the infant at the testing time is a crucial variable which can influence the results obtained. Olfactory research mostly involved sleeping infants in order to reduce the state factor (Engen et al., 1963; Lipsitt et al., 1963; Engen and Lipsitt, 1965; Self et al., 1972; Sarnat, 1978; Russell, 1976; Balogh and Porter, 1986), but various criteria and descriptions of the sleeping state have been adopted. While Engen et al., 1963; 1965 described an infant to be asleep when eyes were closed, respiration was steady and regular, and activity was at a minimum, Balogh and Porter (1986) tested infants in active sleep (eyes closed, irregular respiration, small movement, state II of Prechtl, 1974). Self et al., (1972) who adopted the same state as in Engen et al.'s (1963) study, kept record of all the changes in state. The comparison of data indicated that the longitudinal irregularly asleep group of infants were much more responsive than the cross-sectional irregularly asleep group of infants. The latter group responded slightly more than the former group in deep sleep. Other investigators have tested only awake babies but used different criteria.

While Macfarlane (1975) and Cernoch & Porter (1985) stimulated the sleeping infant to an alert state (Prechtl state 4 or 5 (eyes open): Prechtl & Beinteman, 1964), Schaal et al. (1980) tested infants when they reached an alert state, (state 4 or 5 (eyes open, gross movements): Prechtl, 1965. However, others did not take into account the state of the infant. In some studies the infants were tested whenever possible, whether asleep or awake (Reiser et al., 1976). In other studies no details were given about the state of the baby. It was only mentioned that infants were awake (Steiner, 1974) or quiet (Rovee, 1969).

Most of the studies which involved discrimination between the biological odours of the mother and a female stranger and which reported preferences for the mother's odour from the 4th day after birth tested alert babies. Conversely, most of those which examined infants' responses to artificial odours and demonstrated the presence of the olfactory threshold in the first day after birth tested sleeping infants. Apparently the state of the infant may account for the difference in age at which olfactory perception is possible. This suggestion is, in part, supported by Lipsitt and Levy's (1959) proposition about electro-tactual **"...thresholds are higher when the baby is asleep..."** (Huntt, Lenard and Prechtl, 1969, in Early Human Development, 1973, p.151).

The main difficulty is that the criteria and definitions of states varied widely between researchers. Secondly, not all distinct brain mechanisms are specific to the descriptive behaviour categories (states) such as level of arousal, level of consciousness, vigilance, deep and light sleep. Most of the investigators have included in their terminology only what their experimental design could have indicated to them (Ashton, 1973 and Prechtl, 1974).

Further, state is not stable. It undergoes a series of changes. Failure to take cognizance of these changes may lead to difficulties in the interpretation of data from studies in which the time course extends across such changes. Infants who were awake at the beginning of the study could have passed into irregular sleep, even during the shortest experiment, and babies who were initially in irregular sleep could have passed into regular sleep in the longer studies. The greatest effect of changes in state is manifested in studies of habituation and familiarization. During a certain amount of time changes in heart rate occur. Repetitive stimulation produces a gradual decrement in heart rate response

(Bartoshuk, 1962). Evidence regarding dishabituation was also obtained from the study of Hutt et al. (1968). If stimulation was continued after "habituation" had occurred, a sudden increase in responsiveness was frequently observed.

There are other methodological differences as to the length of stimulus presentation, number of stimuli, presentation of stimulus (single or paired comparison), distance separating the olfactory stimulus from the infant's nostrils, environmental conditions, etc.

Summary and Conclusion

In the studies reviewed above there is strong suggestive evidence that newborn infants can perceive odours soon after birth. Their olfactory thresholds are not only functioning but also change within the first few days following birth. Moreover, breast-feeding infants at ages ranging from 4 days to 6 weeks orient preferentially to the odour (breast, axillary, secretions) of their mother. They do prefer their mother's odours even when mixed with artificial odorants (perfumes and make-up). Thus, whatever the odour of the mother is, whether human or artificial, it is this odour they recognize and prefer to odours of a lactating female stranger. It follows that as early as 4 days of age, the infant can make use of olfactory information in the discrimination process when tested independently of visual and auditory cues. Neonates' ability to discriminate their mother's biological odour also develops with increasing age.

The methodology enabling the study of olfactory perception in the newborn infant has been improving over the past 25 years, but as of yet no clear conclusion about some aspects of the neonate's olfactory abilities can be drawn. Still data rely on physiological reactions and on the observer's judgements rather than automatically recorded responses which could be viewed repeatedly.

The other methodological issues which have emerged as important in increasing the understanding of olfactory abilities of the neonate infant are: controlling for variables such as stimulus type and its chemical composition and state of the infant; using more than one response measure and having an independent assessment of the videotaped responses of the infants to achieve more reliability and validity. Variables such as number of stimuli, length of stimulus presentation, distance between the stimulus and nostrils of the infant and presentation of stimulus - paired or single- can influence the results.

It is certainly difficult to accomplish all of these methodological criteria in a single study and therefore in drawing conclusions it is best to take into account a range of studies using different approaches which can be seen as complementary to one another.

AIMS AND HYPOTHESES

This next chapter examines the effect of olfactory information on early face discrimination. Which information do the neonates use to discriminate and recognize their mother's face? Is it visual, olfactory or both? If both which one is the most important and its absence prevents early face discrimination.

Chapter 4

EXPERIMENTS INVESTIGATING THE ROLE OF OLFACTORY INFORMATION IN EARLY FACE RECOGNITION

Introduction

This chapter describes three experiments designed to examine the effect of olfactory information on early face discrimination. Following the results of the previous study it was suggested that while neonates appear to learn some visual aspects of their mother's face in the first hours after birth, this may actually be explained by infants using olfactory cues to recognize the mother. The fourth experiment is a control one. It explores the possibility that mothers attempted to capture their infants' attention during testing.

The literature on olfactory perception in young infants demonstrates that the olfactory system is functioning in the neonatal period. Perhaps the most compelling evidence is that neonates preferentially orient towards or respond to body odours of their own mother compared with those from unfamiliar mothers (Russell, 1976; Schaal et al., 1980). For example Macfarlane (1975) found in a pioneering study that infants at 5 days of age spent more time orienting towards a breast pad which was previously worn by their lactating mother than towards an adjacent breast pad which was odourless or had been worn by an unfamiliar lactating mother. This preferential response which was absent at 2 days of age, became stronger between 8-10 days. Similarly, Schaal et al. (1980) found 4 day-olds capable of recognizing their own mother's breast, neck and shoulder odours.

Russell (1976) also reported an increase in olfactory recognition across the first few days of life. Infants oriented and began sucking towards their mother's breast pad rather than to that of a strange mother. This differential olfactory identification and recognition was not present at 2 days of age but was at 2 weeks and became stronger after 6 weeks.

In Cernoch and Porter's (1985) study, breast-fed neonates of 2 weeks of age preferentially oriented towards axillary odours from their mother relative to axillary odours from a lactating strange mother. In contrast, the bottle-fed infants failed to show this phenomenon, suggesting that the breast-fed are more capable of recognizing and discriminating maternal smell. Infants, however, failed to distinguish their fathers' axillary odours when paired with those of an unfamiliar male.

Studies which used artificial olfactory stimuli reported discrimination within the first days after birth (e.g. Engen et al., 1963; Lipsitt et al., 1963; Engen et al., 1965; Rovee, 1969; Self et al., 1972; Sarnat, 1978) though, many of these studies used irritating stimuli which stimulated both the olfactory and the trigeminal nerves. They also noted that neonates turned away from unpleasant odours after some experinence of them. Bower (1974, p.19) also suggested the infants' ability to localize the positions of smell sources.

Thus studies investigating the young infants' response to artificial odours tested and demonstrated olfactory discrimination earlier than studies examining infants response to human odours. Since some studies of the first group reported decrement in olfactory perception over time, especially during the first 3 days of life, infants might have shown such an effect in Russell's (1976) study for example. Perhaps at 2 days their sensitivity decreased but increased again around 2 weeks of age. Also most of the studies of the first group tested sleeping infants and apparently thresholds are higher when the baby is asleep. The state of infants did not only differ from one group of studies to another but also within the same group. While Russell (1976) tested 2 day- and 2 week-old infants when sleeping, Cernoch and Porter (1985) examined 2 week-old infants in an alert state. Macfarlane (1975) and Schaal et al. (1980) also studied alert infants but adopted different state descriptions and criteria.

Thus evidence indicates that olfactory discrimination is possible in the neonatal period and that maternal odours can be recognized by neonates from at least the fourth day after birth at a distance of about 1-2 centimeters. Yet there is no evidence that a neonate, a few hours after birth, can recognize maternal odours.

The general aim of this chapter is to examine the role of olfactory information in early face discrimination. Does the neonate use both visual and olfactory information ? If both, which one is the more important and does its absence prevent early face recognition. To answer this question, it was decided firstly to include a control over olfactory cues, and secondly to prevent neonates from seeing the face of their mother and that of the stranger, but to allow their odours to reach the subjects, so any discrimination would be on the basis of olfactory information.

Experiment 4.1

Mother versus non-parturient, non-lactating female stranger: Absence of olfactory information

Introduction

This experiment aims to test the hypothesis that both visual and olfactory information are used by newborns in the discrimination process, but that the absence of olfactory cues would not prevent early face recognition.

Since experiment 2.1 and Field et al.'s (1984) study did not control for olfactory information but both reported early face recognition, it was decided to discard olfactory information, and use two non-parturient non-lactating female strangers to reduce the potential odours resulting from parturient and lactation.

Since the existing evidence suggests that breast-fed infants orient preferentially to the odour of their mother, it was decided to use in this experiment only bottle-fed infants to discard the possibility of learning or development associated with exposure to maternal olfaction.

To reduce the contrast which was obvious in the face of stranger1 in the previous experiment, it was decided to use two female strangers with similar facial brightness.

To further investigate the sex effect found in experiment 2.1, it was seen to be advisable to include sex as a factor in this study.

Method

Subjects

These were thirty caucasian neonates (16 males, 13 females) volunteered by their mothers on the wards of the Royal Maternity Hospital, Glasgow. Of these subjects, 5 babies were excluded because they failed to look at both alternatives during the discrimination test and therefore showed side bias in their behaviour. Thus the final sample consisted of 24 subjects (12 males and 12 females). Their mean age was 61.83, sd=3.65, ranging from 12 to 155 hours. The difference between male and female subjects in age at testing was not significant by t-test (t=-0.81, df=22, ns). Their mean birth weight was 3.28, sd=0.34, ranging from 2.63 to 4.22 kg. The difference between the subjects in birth weight was not significant by t-test (t=1.55, df=22, ns). Table 4.1.1 shows the subjects' sex, age, birth weight and Apgar scores.

The neonate infants were all full term babies, healthy as indicated by their Apgar scores at birth (Mean Apgar score at 1 and 5 mn after birth was 8.33 and 9.79 respectively, (see Appendix 2.1 for details on the apgar scores). Of the 24 subjects, the birth method of 14 was normal (SVD), 6 were forceps delivery (MCFD) and 4 were sectioned (LUSCS). Chapter 2 provides explanations of these methods.

Table 4.1.1. Subjects' sex, age, birth weight and Apgar scores (N=24)

Ss	Sex	Age (hrs)	Birth weight (kg)	Apgar at: 1mn	5mn
1	M	33.04	3.18	5	10
2	M	20.27	3.26	9	10
3	M	87.46	3.48	9	10
4	M	34.08	3.66	9	9
5	M	79.52	3.66	9	10
6	M	71.21	3.85	9	10
7	M	88.50	3.05	9	10
8	M	44.55	3.07	9	10
9	M	43.57	3.41	9	10
10	M	21.35	3.62	9	9
11	M	83.35	3.37	9	10
12	M	62.15	3.17	6	9
13	F	38.30	2.63	9	9
14	F	77.71	2.71	9	10
15	F	50.01	2.89	9	10
16	F	65.91	3.67	9	10
17	F	119.51	2.99	9	10
18	F	131.54	3.39	5	10
19	F	28.45	3.11	9	10
20	F	155.02	3.28	9	10
21	F	30.40	3.13	9	10
22	F	12.20	3.16	9	10
23	F	41.56	4.21	8	10
24	F	65.48	2.84	5	9
Mean		61.88	3.28	8.33	9.79
Sd		3.65	0.34	1.4	0.4

Apparatus / Stimuli

The faces of two non-parturient, non-lactating female strangers were used randomly in this experiment. The two strangers had almost similar hair colour (fair) and length (shoulder length). Also, they both had a pale complexion.

Procedure

The same procedure was adopted as in the previous experiment with subjects being tested in the same location and at the same time of day. All subjects were alert and calm (state 3, Prechtl, 1974). Since the aim of the study is to examine whether newborn infants demonstrate preference for their mother's face over a female stranger's face it was decided to use a spontaneous visual preference technique as in the previous experiment with infants being presented with both the mother's and stranger's faces over two trials, each of 20 secs duration.

In the experiment reported below, neonates were tested for their ability to discriminate their mother's face while both the mother's and stranger's olfactory cues were masked by an air-freshner (Stephanotis-Room Floral Fragrance). The odorant was liberally sprayed onto the screen surrounding the faces of the mother and the stranger (see experiment 2.1 for details about apparatus). This material was sprayed three times; before the subject and participants (mother and stranger) came into the testing room and immediately before each of the two trials for each subject. The masking odour was sufficiently strong that no other odour could be detected according to adults' judgments. It lasted even after the sheet was washed out many times.

Results

The most important aspects of the present data are the amount of fixation elicited during the test trials, and the total amount of fixation directed to the mother relative to the stranger. These fixation times for both the mother and stranger's faces were expressed in terms of percentages and are listed in Table A below. Table 4.1.2 presents the means. Figure 4.1.1 illustrates these means.

Table A **Percentage fixation times (in seconds) for the mother and the stranger**

Trial1		Trial2		Combined Trials	
Stranger	Mother	Stranger	Mother	Stranger	Mother
Male					
30.40	69.60	0.00	100.00	15.20	84.80
18.20	81.80	12.80	87.20	15.50	84.50
10.35	89.65	2.05	97.95	6.20	93.80
48.50	51.50	16.05	83.95	32.30	67.70
5.45	94.55	69.70	30.30	37.50	62.50
4.90	95.10	9.45	90.55	7.20	92.80
6.10	93.90	26.00	74.00	16.00	84.00
74.15	25.85	76.30	23.70	75.25	24.75
0.00	100.00	51.05	48.95	25.55	74.45
0.00	100.00	8.40	91.60	4.20	95.80
72.30	27.70	0.00	100.00	36.20	63.80
47.10	52.90	23.50	76.50	35.30	64.70
Female					
25.10	74.90	0.00	100.00	12.50	87.50
5.00	95.00	22.50	77.50	13.70	86.30
9.95	90.05	0.00	100.00	5.00	95.00
18.60	81.40	40.20	59.80	29.40	70.60
71.25	28.75	29.60	70.40	50.45	49.55
12.30	87.75	33.40	66.60	22.80	77.20
76.00	24.00	38.15	61.85	57.10	42.90
0.00	100.00	59.60	40.40	29.80	70.20
51.30	48.70	0.00	100.00	25.65	74.35
0.00	100.00	0.00	100.00	0.00	100.00
36.20	63.80	43.10	56.90	39.60	60.40
40.65	59.35	57.10	42.90	48.90	51.10

Table 4.1.2 Mean percentage preference for the mother across Sex (Male and Female) and Trials (Trial1 and Trial2)

	Trials				
	Trial 1		Trial 2		
	Mean	SD	Mean	SD	Average
Male	73.5	27.5	75.4	26.7	74.5
Female	71.1	26.5	73.0	22.4	72.1
Average	72.3		74.2		

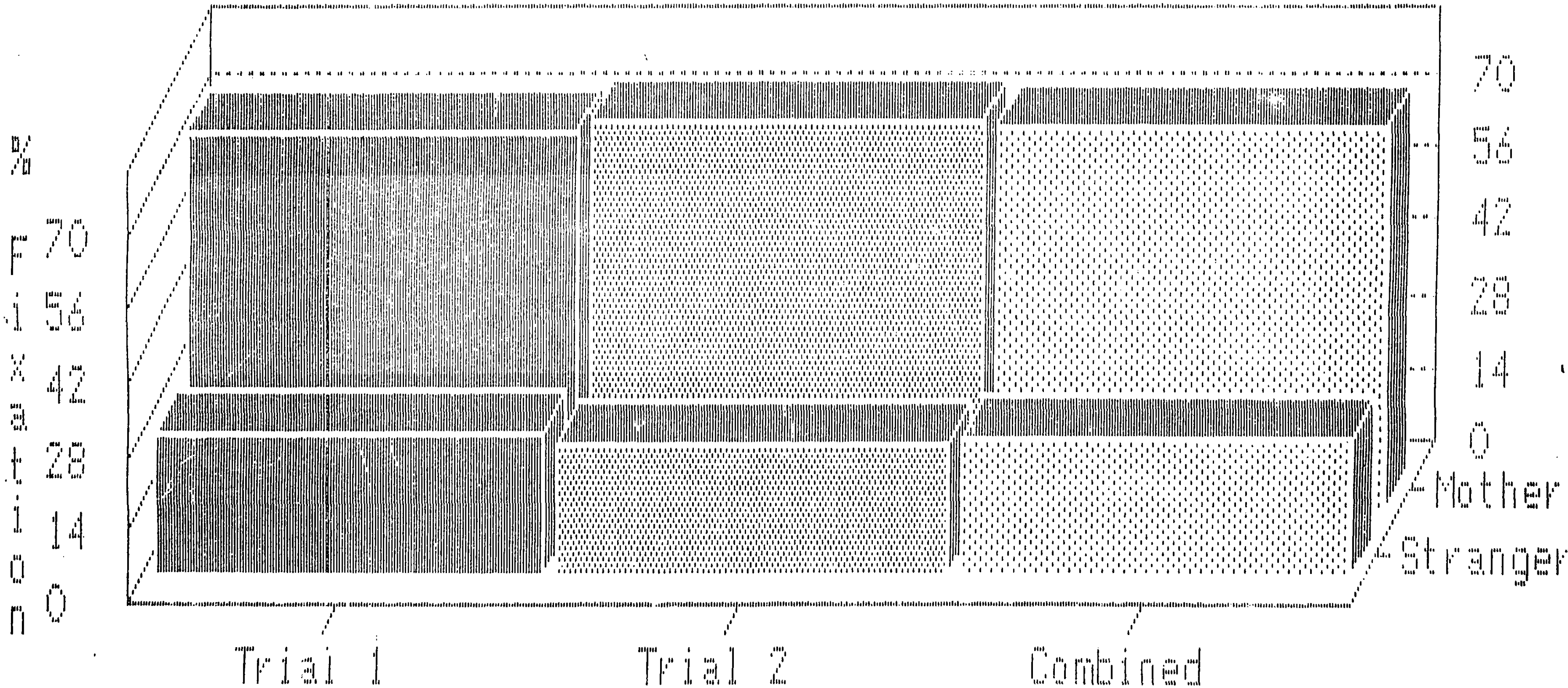


Figure 4.1.1. Percentage préference for the mother and the stranger across trials.

Mother-stranger face discrimination

A two-way analysis of variance was carried out, considering one within subjects variable - Trials (Trial 1 and Trial 2) and one between subjects variable - Sex (Male and Female) using the percentage preferences data for the mother's face across trials. The analysis revealed neither a significant Sex effect ($F(1, 22)=0.09$, NS) nor Trials effect ($F(1, 22)=0.06$, NS), suggesting that there was no significant difference between male neonates (M=74.5%) and females (M=72.1%). Nor was there a significant difference in preference for the mother across trials. Neonates looked at their mother's face on Trial2 (M=74.2%) almost the same as they did on Trial 1 (M=72.3%). Table 4.1.2 shows the means and standard deviations. The Sex X Trials interaction effect was also non-significant ($F(1, 22)=0.00$, ns). The ANOVA summary table is presented in Table 4.1.3.

Table 4.1.3 Percentage preference for the mother across Sex (Male and Female)and Trials (Trial1 and Trial2

Source	Sum of Squares	DF	Mean Square	F ratio	P.value
Sex	68.1631	1	68.1631	0.09	NS
Error x Sex	16088.3342	22	731.2879		
Trials	41.8132	1	41.8132	0.0691	NS
Sex X Trials	0.0055	1	0.0055	0.0000	NS
Sex X Trials X Subj.Error	13310.2186	22	605.0099		

Further, to examine whether there was preference for the mother's face on Trial 1, Trial 2 and on the combined Trials, correlated t-tests were computed. The percentage fixations to the mothers are set out in Figure 4.1.1 from which it can be seen that overall fixation times to the mother's face were much longer than to the stranger's face. The relative means are shown in Table 4.1.4. There was a significant preference for the mother's face on Trial 1 ($t=-4.13$, $df=23$, $p<0.0005$, one-tailed), on Trial 2 ($t=-4.91$, $df=23$, $p<0.0005$, one-tailed) and on the combined trials ($t=-6.08$, $df=23$, $p<0.0005$, one tailed). Table 4.1.5 illustrates these differences.

This demonstrated preference for the mother could be attributed to a lack of preference for the strangers. A control study which is designed to present the same mother-stranger pairs but where no subject is shown his/her own mother would clarify this matter.

Table 4.1.4 Mean percentage fixation times to the mother's face on Trial 1, Trial 2 and on the combined trials

	Trial 1 (%)	Trial 2 (%)	Combined Trials (%)
Mean	72.3	74.2	73.3
Standard Deviation	26.45	24.12	18.75
Variance	699.5623	581.5996	351.5069
Average Deviation	22.60729	20.04288	14.82257
Coefficient of Variance (%)	36.5605	32.49729	25.58506

N=24

Table 4.1.5 One-tailed-tests for mother's face preference on Trial 1, Trial 2 and the combined Trials

	DF	t	P. Value
Trial 1	23	-4.13*	p<0.0005
Trial 2	23	-4.91*	p<0.0005
Combined Trials	23	-6.08*	p<0.0005

* p<0.0005

Effect of age at the time of testing on preference for the mother's face

To assess the effect of age at testing on preference for the mother's face, a 2x2 (Sex x Age) analysis of variance was applied to percentage fixation times for the mother's face. None of the variables attained significance, showing there was no difference between younger babies (<36 hrs) (M=78.6%) and older neonates(>36 hrs) (M=71.1%) ($F(1, 20)=0.58$, NS), nor was there a sex effect ($F(1, 20)=0.25$, NS). Also, the Sex x Age interaction effect was not significant ($F(1, 20)= 0.51$, NS). Table 4.1.6 presents the means from which it can be seen that younger males performed slightly better (M=83.2%) than older males (M=70.1%), though this difference was not significant. But younger (M=72.4%) and older females (M=72%) fixated their mother equally. The ANOVA summary table is reported in Table 4.1.7.

Table 4.1.6 Means percentage preference for the mother's face across Sex (Male and Female) and Age (>36 and <36 hrs)

		Age		
		<36 hrs	>36 hrs	Average
	Male	83.2	70.1	74.5
Sex	Female	72.4	72	72.1
Average		76.6	71.1	

N=24

Table 4.1.7 Two-way ANOVA for preference for the mother's face across Sex (Male and Female)and Age (>36 hrs and <36 hrs)

Source	Sum of Squares	DF	Mean Square	F.ratio	P.Value
Sex	96.142	1	96.142	0.252	NS
Age group	224.321	1	224.321	0.589	NS
Sex x Age group	196.58	1	196.58	0.516	NS
Error	7610.941	20	380.547		

N=24

<u>The relationship between the infant's age age at testing and extent of preference for the mother's face.</u>

The relationship between age at the time of testing and extent of preference for the mother's face over the combined trials was assessed by Pearson's-Product-Moment

Correlation and a negative non-significant correlation was found ($r=-0.13$, ns) indicating that mother's face preference does not increase with the increasing age of the infant.

The relationship between the infant's birth weight and preference for the mother's face.

The relationship between birth weight and preference for the mother's face was assessed by a Pearson's-Product-Moment and a non-significant correlation ($r=0.24$, ns) was obtained, suggesting that heavier babies did not differ from lighter neonates in their visual behaviour.

Stranger's effect on preference for the mother

To determine whether there was any difference in preference for the mother's face between neonates who were shown the face of stranger 1 and those who were presented with the face of stranger 2, a two-way analysis of variance with two between subjects variables - Sex (male and Female) and Condition (Condition 1 and Condition 2) was computed. Stranger 1 was shown to 5 males and 6 females whereas stranger 2 was paired with the mother for 7 males and 6 females. No significant main effect for Condition ($F(1, 20)= 0$, NS) or for Sex ($F(1, 20)=0.35$, NS) was found. However, the Sex x Condition interaction ($F(1, 20)= 8.92$, $p<0.01$) reached a high level of significance. Reference to Table 4.1.8 shows that male subjects who had been presented with stranger 1's face appeared to prefer their mother's face (M=86.4%) more than males whose mother's face was paired with the face of stranger 2 (M=65.9%). Conversely, females who were exposed to the face of stranger 2 looked at their mother's face (M=82.4%) more than the female infants who saw the face of stranger 1 (M=61.8%). Table 4.1.9 illustrates the ANOVA summary table.

A multiple t ratio were used to compare the performance of male and female subjects across conditions and this resulted in significant t values for male on condition 1 ($t(20)=5.10$, $p<0.001$), for female on condition 2 ($t(20)=-3.40$, $p<0.01$).

Table 4.1.8 Mean percentage preference for the mother's face for male and female neonates across Conditions (Stranger1 and Stranger2)

		condition 1 (%)	condition 2 (%)	Average
	Male	86.4	65.9	74.5
Sex	Female	61.8	82.4	72.1
	Average	73	73.5	

Table 4.1.9 Two-way ANOVA for preference for the mother's face across Sex and Condition

Source	Sum of Squares	DF	Mean Square	F.ratio	P.Value
Sex	98.326	1	98.326	0.35	NS
Condition	0.03	1	0.03	0.00	NS
Sex x Condition	2484.773	1	2484.773	8.929*	$p<0.01$
Sex x Condition x Subj.Error	5565.33	20	278.266		

* $p<0.01$

Birth order effect on preference for the mother's face

To determine whether there were differences in fixations for the mother's face between first and non-first born infants, a two-way analysis of variance was performed using two between subjects variables - Sex (Male and Female) and Birth order (First born and Non-first born), on percentage preference for the mother's face. The means are set out in Table 4.1.10 where it can be seen that non-first borns looked at their mother's face (M=79.9%) more than first borns (M=68.5%). Both non-first born males (M=82.1%) and females (M=77.8%) showed slightly greater preference for the mother's face than did first born males (M=69%) and first born females (M=68%), though Birth order effect failed to reach significance ($F(1, 20)=2.09$, NS). Both Sex effect ($F(1, 20)= 0.11$, NS) and Birth order x Sex interaction effect ($F(1, 20)= 0.04$, NS) were not significant. The ANOVA summary Table 4.1.11 shows these data.

Table 4.1.10 Mean percentage preference for the mother's face across Sex (Male, Female) and Birth order (First born, non-first borns)

		Birth order		
		First born (%)	Non-first born (%)	Average
	Male	69	82.1	74.5
Sex	Female	68	77.8	72.1
	Average	68.5	79.9	

Table 4.1.11 Two-way ANOVA for preference for the mother across Sex and Birth order

Source	Sum of Squares	DF	Mean Square	F.ratio	P.Value
Sex	40.733	1	40.733	0.111	NS
Birth order	761.761	1	761.761	2.094	NS
Sex x Birth order	15.073	1	15.073	0.041	NS
x Subj.Errror	7274.034	20	363.701		

Number of fixations for the mother and stranger

A two-way analysis of variance was carried out on the number of fixations for the mother's face with a single within subjects variable - Trials (Trial 1 and Trial 2) and one between subjects variable - Sex (Male and Female). The main effect for Sex was not significant ($F(1, 22)=0.34$, NS), nor was the Trials effect ($F(1, 22)=0.4$, NS). The interaction Sex x Trials effect was also not significant ($F(1, 22)=0.07$, NS). From Tables 4.1.12 and 4.1.13 it can be seen that the non-significant effect of sex revealed no difference between males and females in number of fixations directed to the mother and stranger. Also, the number of fixation for the mother and stranger did not differ across trials. The absence of a significant Sex x Trials interaction indicates that the performance of male and female neonates did not differ across Trials. Inspection of the means illustrates that on average neonates looked at the faces of the mother and stranger 6 times in 20 secs on Trial 1. Four of 24 subjects looked continuousely for 20 sec at the mother. The remaining 20 infants' number of fixations varied between 2 and 12 in 20 secs. On Trial 2, 6 of 24 fixated constantly their mother. Similarly, the other 18 neonates' number of fixations varied between 2 and 12 during 20 secs.

Table 4.1.12 Means Number of Fixations for the mother and stranger across Sex and Trials

		Trials		
		Trial 1	Trial 2	
		Mean	Mean	Average
Sex	Male	5.9	6.7	6.3
	Female	6.8	7.2	7
	Average	6.4	6.9	

Table 4.1.13 Number of Fixation for the mother and stranger across Sex (Male and Female) and Trials (Trial1 and Trial2)

Source	Sum of Squares	DF	Mean Square	F.ratio	P.Value
Sex	5.3333	1	5.3333	0.3478	NS
Sex x Error	337.3333	22	15.3333		
Trials	4.0833	1	4.0833	0.4062	NS
Sex x Trials	0.7500	1	0.7500	0.0746	NS
Sex x Trials x subj.Error	221.1667	22	10.0530		

Number of changes in fixations between the faces of the mother and stranger

To find out if the neonates had sampled both the mother's and stranger's faces on both trials, a two-way analyses of variance was computed using the number of changes in fixations between the two faces, and considering one within subjects variable - Trials (Trial 1 and Trial 2), and one between subjects variable - Sex (Male and Female). The means number of changes in fixations are set out in Table 4.1.14. The analysis revealed no significant effect for Trials ($F(1, 22)=0.37$, NS), nor was the Sex effect significant ($F(1, 22)=0.46$, NS). Also, the Sex x Trials interaction was not significant ($F(1, 22)=0.15$, NS). The ANOVA summary table is reported in Table 4.1.15. Inspection of the means indicates that overall the neonates sampled the mother and stranger's faces almost the same number of times on the two trials (Trial 1 ($M=2.9$) and Trial 2 ($M=3.4$). Males ($M=3.5$) also did not differ significantly from females ($M=2.9$) in the number of changes in fixations between the two faces.

Table 4.1.14 Means number of Changes in fixations between the mother and stranger's faces across Sex (male and Female) and Trials (Trial1 and Trial2)

		Trials		
		Trial 1	Trial 2	Average
	Male	3.1	3.8	3.5
Sex	Female	2.8	3	2.9
	Average	2.9		3.4

Table 4.1.15 Number of Changes in fixations between the mother and stranger's faces across Sex and Trials

Source	Sum of Squares	DF	Mean Square	F.ratio	P.Value
Sex	3.5208	1	3.5208	0.4686	NS
Error x Sex	165.2917	22	7.5133		
Trials	2.5208	1	2.5208	0.3774	NS
Sex x Trials	1.0208	1	1.0208	0.1528	NS
Sex x Trials x subj.Error	146.9583	22	6.6799		

Discussion

The aim of this experiment was to test the hypothesis that newborn babies use both visual and olfactory information to discriminate their mother's face and that the absence of olfactory information would not prevent early face discrimination. The fixation times paid to the mother confirm this hypothesis. The absence of olfactory cues did not affect the discrimination process.

The present results also support both Field et al.'s (1984) study and the findings of experiment 2.1 that newly born infants are able to discriminate between the face of their mother and that of a non-parturient, non-lactating female stranger. The most surprising result is the demonstration of such very early face discrimination even when hair colour and facial brightness varied non-systematically across subjects and olfactory information was not available

The current results confirm neither Field et al.'s findings suggesting stronger preference for the mother on the part of female neonates, nor do they support the results of Experiment 2.1 of a sex effect in the opposite direction. However, they did show a slight tendency for greater preference for the mother's face on the part of males.

The present experiment also investigated whether bottle-fed infants can discriminate their mother's face from that of a non-parturient, non-lactating female stranger. Evidence suggests that unlike breast-fed infants, the bottle-fed infants are less familiar with their mother's odours and therefore are unlikely to recognize their mother's odours (Cernoch & Porter, 1985). The percentage preference for the mother's face indicated that even bottle-fed neonates who were not exposed directly to their mother's bodily odours and have less experience with their mother's smell can demonstrate early face dicrimination. This finding suggets that neonates may learn some visual aspects of their mother's face within the first day after birth. The possibility that bottle-fed infants are less sensitive to their mother's odours cannot, however, be discarded. First, the difference reported by Cernoch and Porter between breast- and bottle-fed infants at 2-weeks of age may not yet have been developed in the first four days. Second, in the present study, neonates were not tested as to whether they could recognize their mother's odour. Since the visual cues were available the bottle-fed could have used this information.

An alternative explanation for the preference for the mother demonstrated by neonates is that it might be due to a lack of preference for the stranger especially because both strangers used in this study had fair hair and had pale complexions. However, the present experiment cannot determine whether the obtained preference resulted from the lack of preference for the stranger. A further study would require a control where the same strangers were used, and the same mothers, but no neonate was shown his/her own mother.

Thus, the present findings suggest that while neonates may be able to discriminate between their mother's face and that of a female stranger on the basis of olfactory information, it is evident that they may make use of visual information in the absence of olfactory cues. It is possible that newly born infants use both visual and olfactory information when available, but the absence of olfactory cues does not seem to prevent the face discrimination process. This suggets that olfactory information may be playing either little or no role in early face discrimination (and possibly recognition), and that visual cues are considerably important.

The fact that males looked more at their mother when paired with stranger1 and females preferred their mother who was paired with stranger2 suggests that this is much more likely to be a sampling error due to small numbers.

The present results confirmed Field et al.'s and the previous experiment's findings of very early face discrimination. Again, the difference between younger babies (<36 hrs) and older neonates (>36 hrs) in the amount of preference for their mother was not statistically significant. This suggests that these results reflect a floor effect, that is the capacity to recognize the mother's face develops in the first hours of birth and that all the infants tested had more than that level of experience. A second explanation is that age does not predict the exact amount of experience the neonate had with the mother's face. Some of the babies sleep more than others and therefore have less experience than neonates who are most of the time alert.

The non-significant relationship between age at testing and the extent of preference for the mother also indicates that preference for the mother does not increase with age. It follows that the newborn baby is either rapid in learning some aspects of the mother's face or in developing associations between the mother's face and her responses.

The fact that there was no significant difference between male and female neonates in their preferences for their mother suggests once more that any sex effect found has probably been arbitrary since it vacillates from one study to another. A larger sample is needed to elucidate this matter

Contrary to experiment 2.1, both male and female non-first borns tended to fixate their mother's face longer than the first born infants did, though this difference was not significant. A further study using a larger sample is required to clarify these results. The consistency of the number of fixations for the mother and stranger across trials indicates that the faces were attended by the neonates equally during the two 20-sec periods. The small number of fixations is due to the length of the fixations. As the length of individual fixations increases, the number of fixations decreases. The number of fixations for the two faces shows that, overall, the neonates were not passive as they did not continually look at one face, but rather seemed also aware of the presence of the face of the stranger. This proposition is supported by the number of changes in fixations between the two faces. The neonates sampled both faces across trials. Apparently, as soon as the infants recognized the stranger's face as "strange", they changed their fixation towards the mother.

Thus, that the length of fixations as an index of preference for the mother's face can be a reliable response measure is supported by the number of fixations for the mother and stranger and the number of times the neonates sampled both faces.

In conclusion, the current experiment indicates that very early face recognition is possible even when olfactory information is unavailable. One suggestion is that either olfactory information is not relevant in the discrimination process or that the olfactory mask was not effective and neonates could still detect the odours of their mothers. Evidence from studies testing neonates' response to artificial odours demonstrated greater sensitivity on the parts of neonates in the first hours following birth than after the third day. Perhaps the odour used to mask the human odours did not mix well with the air contained in the room or did not last. Here one can argue that most of the mothers and strangers commented on the strength of the odour when coming into the testing room. The odour appears to have lasted more than 5 minutes and obviously it took much less time than that to test an infant. The hypothesis that neonates might be too sensitive to the mother's odours can neither be supported nor rejected at this stage. An experiment designed to investigate whether the neonate can recognize the location of the mother at 30 cm on the basis of olfactory cues is more likely to clarify early sensitivity to odours.

Also the present results could have been biased because of the use of two female strangers. There might have been a bias too on the part of the observer (author) recording the visual fixations as a result of knowing the identity of the mother and the hypothesis tested. A more sensitive examination of these variables would involve the introduction first of a control over face and hair brightness and the use of a "blind" observer to record the fixation times and infant holder.

Conclusion

From 12 hours of age neonates are able to discriminate their mother's face from that of a non-parturient, non-lactating female stranger. They may utilise both visual and olfactory information but they can only use visual cues when olfactory information is unvailable. Even bottle-fed babies can make finer discriminations between their mother's face and the face of a strange female when olfactory cues are unavailable.

Experiment 4.2

Mother versus parturient, lactating female stranger: Absence of olfactory information

Introduction

The results of Experiment 4.1 indicated that neonates can discriminate between the faces of their mother and that of a non-parturient, non-lactating female stranger even when the olfactory cues of both the mother and stranger were masked. These findings, however do not allow one to ascertain that olfactory information is not used by newborns in discriminating their mother. In fact the infants were not tested as to whether they recognize their mother only through odours. The existing evidence suggests that young infants from the fourth day of age not only are able to detect odours, but respond preferentially to the odours of their own mothers paired with those of unfamiliar mothers (Macfarlane, 1975; Russell, 1976; Schaal et al., 1980 and Cernoch and Porter, 1985). Yet there is no evidence that infants only a few hours of age can recognize their maternal odours. One suggestion made at the end of experiment 4.1 was that neonates may be capable of recognizing their mother odours, but can make use of visual information when olfactory cues are unavailable. Before making such a proposition a further study is needed.

The present experiment is an attempt to provide further control over olfactory information by including newly parturient, lactating female strangers. Since neonates might be so sentitive to the lactating odours of their mothers, it was seen to be advisable to present the infant with two lactating females (the mother and stranger) and see whether the neonate could still show preference for the mother over the stranger.

As evidence suggests that breast-fed infants of 2 weeks of age preferentially oriented towards the axillary odours of their mother, whereas the bottle-fed infants failed to demonstrate any preference for the mother (Cernoch and Porter, 1985), it was decided to test a group of breast-fed, and a group of bottle-fed infants, and compare their visual behaviour.

To determine that preference for the mother was not affected by overall brightness of the comparison faces it was decided to match closely the mother's face with that of a newly parturient female stranger for hair colour, hair length, and facial complexion, and use one stranger for each subject. Both in Field et al.'s study and in Experiments 2.1 and 4.1 of this thesis hair colour and facial brightness cues were not controlled across subjects. Field et al. did not provide a description of the physical characteristics of the female strangers they used. In experiments 2.1 and 4.1 the hair colour of the mother was sometimes darker and sometimes lighter. Likewise the mother's face was sometimes brighter and some other times it was less bright than the stranger's.

In the two previous experiments it was not possible to check the reliability of the observer's recordings of infants' fixations. Although the running of "blind" experiments was necessary to provide more control over experimenter bias, it was difficult because the present research is an individual project. In the present experiment, only the second half of the sample (10 subjects) were tested with the observer and baby-holder blind as to the identity of the subject's mother and the stranger. Details about this control over experimenters' bias are provided in the procedure section below. The first half of the sample (10 subjects) was not tested blind. Both observer and infant-holder did not know that a further control for experimenter bias was to be incorporated and could not have accordingly changed their behaviour when testing the first group. Thus comparing data from the first 10 with the second 10 provides an extra check on deliberate or 'unconscious' bias.

Finally, since there was a sex effect with male neonates demonstrating slightly stronger preference for the mother's face in experiment 2.1 it was felt profitable to include sex as a factor in the present experiment.

Method

Subjects

Twenty nine babies and their mothers participated in this experiment. Five neonates were excluded because of side bias in their looking behaviour during the test trials. Three other infants were discarded because there was not a good match between the mother and stranger's faces in terms of hair colour. Another subject was removed from the study because she was premature and was not known to be so before testing. The final sample thus consisted of 20 Caucasian neonates (10 male and 10 female). Their mean age was 50.41 hrs, sd = 27.35, range 11.57-100.5 hours. The difference between the two sexes in age was not significant by t-test (t = 0.62, df = 19, NS). The birth weights of the subjects ranged from 2.40 to 4.21 Kg, with a mean of 3.27 Kg, sd = 0.58. Again the difference between male and female subjects in birth weight was not significant by t-test (t = 0.53, df = 19, NS).

The subjects were apparently normal and healthy as judged by their Apgar scores at birth (Mean Apgar was 8.39, sd = 1.11 ranging from 5 - 9 at 1 min and 9.5, sd = 0.92 at 5 mins after birth, ranging from 6 - 10). <u>Table 4.2.1 presents the subjects' sex, age birth-weight and Apgar scores.</u>

The birth method of 13 of the 20 subjects was normal

(SVD), 4 were forceps (MCFD) and 3 were sectioned (LUSCS).

The subjects were divided into two groups (blind and not bind). Both sexes were equally represented. Each group consisted of equal numbers of breast-fed and bottle-fed infants.

Table 4.2.1 Subjects' sex, age, birth weight and Apgar scores (N= 24)

	Ss	Sex	Age (hrs)	Birth weight (kg.)	Apgar at: 1min	5mins
Not blind Condition	1	M	12.33	3.14	9	10
	2	M	62.15	3.17	6	6
	3	M	83.35	3.37	9	10
	4	M	85.35	2.54	9	10
	5	M	96.80	2.70	9	10
	6	F	11.57	3.37	9	10
	7	F	12.20	3.16	9	10
	8	F	41.56	4.21	8	10
	9	F	65.48	2.84	5	9
	10	F	100.50	2.69	9	9
Blind Condition	11	M	30.56	3.84	8	10
	12	M	32.50	3.32	9	10
	13	M	36.55	3.50	8	9
	14	M	52.00	4.8	9	10
	15	M	52.33	3.12	9	10
	16	F	15.57	3.13	9	10
	17	F	36.50	2.40	7	9
	18	F	43.48	4.16	9	10
	19	F	61.00	2.99	9	9
	20	F	76.20	3.09	9	9
	Mean		50.41	3.27	8.39	9.51
	Sd		27.35	0.58	1.11	0.92

Procedure

The same method was adopted to as that in the previous experiments with subjects of the same area (Glasgow), being tested in the same Hospital and at the same time of day. The same air-freshner was used. However this experiment included two additional experimenters. Their role was to obtain subjects on the wards of the Hospital and find suitable matching faces, that is, two faces with equivalent hair colour, hair length and shape and face complexion. Further, they explained the aim and procedures to the mother and stranger and asked them not to reveal their identity to the experimenters waiting in the room. Thus, each subject was brougnt into the testing room by a 'recruting' experimenter, followed by the two females, acting in a neutral fashion towards the subjects so that the observer and baby holder would not know the mother and bias the data. The mothers of three subjects revealed their identity and were excluded from the sample.

Results

The obtained visual fixation times were expressed into percentages and are set out in <u>Table A</u> below. Table 4.2.2 illustrates the means.

Table A **Percentage fixation times (in seconds) for the mother and the stranger**

Trial1		Trial2		Combined Trials	
Stranger	Mother	Stranger	Mother	Stranger	Mother
Not Blind					
Male					
12.50	87.50	95.90	4.10	33.50	66.50
3.70	96.30	37.20	62.80	20.00	80.00
51.20	48.80	46.00	54.00	48.70	51.30
94.30	5.70	66.95	33.05	80.60	19.40
7.00	93.00	16.60	83.40	11.25	88.25
Female					
29.65	70.35	30.80	69.20	30.23	69.77
0.00	100.00	64.00	36.00	32.00	68.00
49.30	50.70	28.85	71.15	39.00	61.00
100.00	0.00	29.10	70.90	64.55	35.45
31.15	68.85	5.90	94.10	18.50	81.50
Blind					
Male					
36.80	63.20	22.05	77.95	29.42	70.58
32.95	67.05	79.75	20.25	56.37	43.63
38.65	61.35	63.10	36.90	51.00	49.00
75.15	24.85	2.10	97.90	38.60	61.40
51.40	48.60	20.50	79.50	35.95	64.05
Female					
46.20	53.80	19.60	80.40	32.87	67.13
10.60	89.40	25.25	74.75	17.92	82.08
56.80	43.20	15.25	84.75	36.03	63.97
51.30	48.70	63.50	36.50	57.37	42.63
69.85	30.15	12.50	87.50	41.17	58.83

Table 4.2.2. Mean percentage fixation times for the mother's face across Sex and Method of Feeding

		Trial 1	Trial 2	Average	
					<u>Male</u>
	Male	63.9	58.8		
Breast				63.7	57.3
	Female	51.1	81.0		
					<u>Female</u>
	Male	55.4	51.2		
Bottle				56.6	63.0
	Female	60.0	60.1		

<u>Mother-stranger face discrimination</u>

Overall, the neonates fixated the mother for a significantly longer time than the parturient female stranger. The percentage fixation times for the mother and stranger on Trial 1, Trial 2 and the combined data are illustrated in <u>Figure 4.2.1.</u>

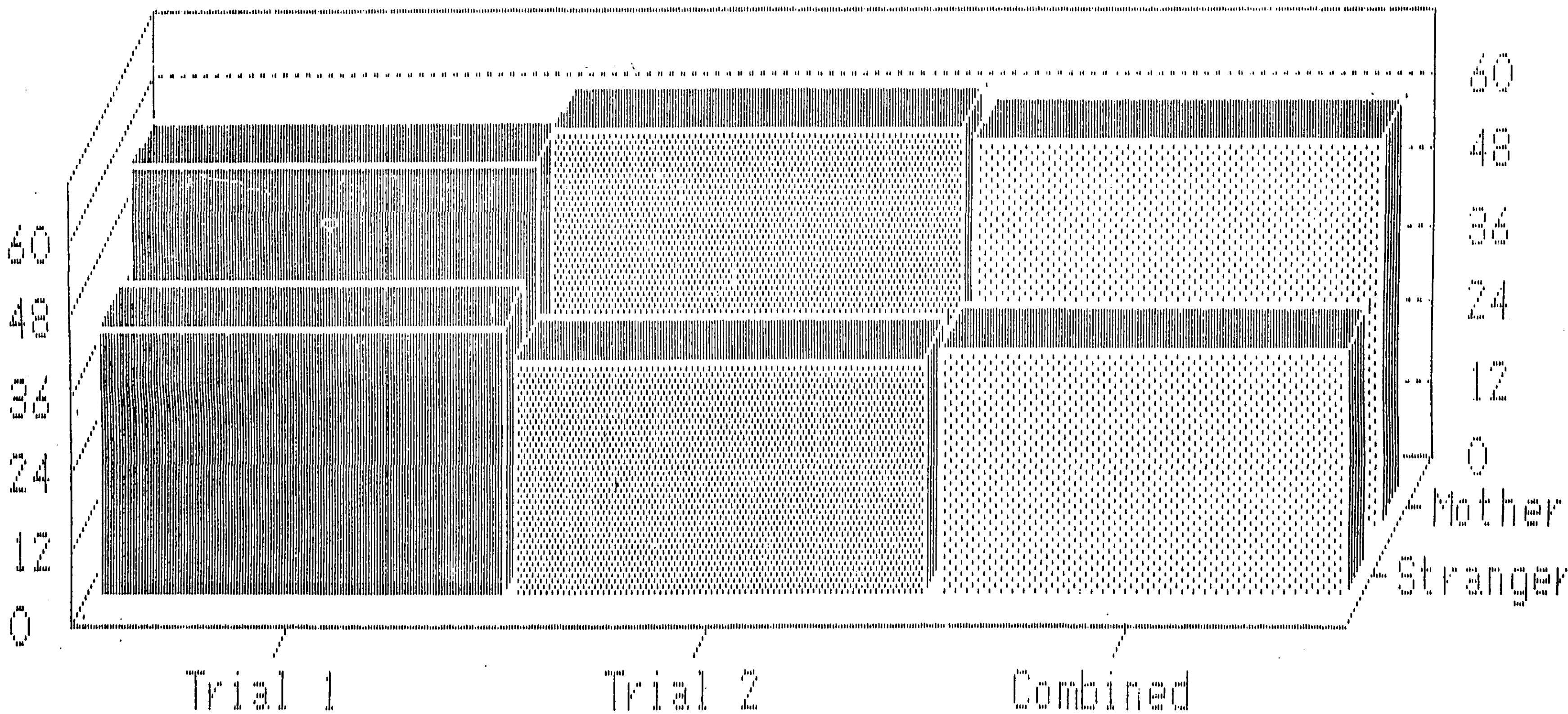


Figure 4.2.1. Percentage preference for the mother and the stranger across trials.

A three-way analysis of variance was performed on the percentage preference for the mother's face, considering two between subjects variables - Sex (Male and Female) and Feeding Method (Breast and Botle) and one single within subjects variable - Trials (Trial 1 and Trial 2). Neither Sex ($F(1, 16) = 0.49$, NS), Method of Feeding ($F(1,16) = 0.28$, NS) nor the Sex x Method of Feeding x Trials interaction ($F(1, 16) = 0.56$, NS) and the Sex x Method of Feeding x Trials intraction ($F(1, 16) = 0.63$, NS) were significant. The means are set out in Table 4.2.2. The Anova summary table is presented in Table 4.2.3.

Table 4.2.3. Preference for the mother's face across sex (Male, Female) Method of Feeding, and Trials (Trial 1, Trial 2)

Source	Sum of Squares	DF	Mean Squares	F. Ratio	P. Values
Sex	326.0412	1	326.0412	0.4937	NS
Feeding	497.0251	1	497.0251	0.7526	NS
Sex x Feeding	11.2358	1	11.2358	0.0170	NS
Sex x Feeding x Subj. Error	10566.7815	16	660.4233		
Trials	268.3242	1	268.3242	0.288	NS
Sex x Trials	966.2888	1	966.2888	1.0372	0.324601
Feeding x Trials	524.1759	1	524.1759	0.5627	NS
Sex x Feeding x Trials	589.8242	1	589.8242	0.6331	NS
Sex x Feeding x Trials x Subj. Error	14905.4345	16	931.5897		

Preference for the mother's face was further examined by a correlated t-test which compared the percentage fixation times paid to the mother with that to the stranger on Trial 1, Trial 2 and on both Trials combined. There was no significant preference for the mother's face on Trial 1 (t = - 1.19, df = 19, NS, one-tailed). Though not very strong, preference for the mother was significant on both Trial 2 ($t = -2.16$, $df = 19$, $p < 0.025$, one tailed) and on the combined trials ($t = -2.94$, $df = 19$, $p < 0.005$). The mean percentage fixation times are shown in Table 4.2.4.

Table 4.2.4. Mean percentage fixation times to the mother on Trial 1, Trial 2 and on the Combined Trials

	Trial 1	Trial 2	Combined Trials
Mean	57.6	62.8	61.2
Standard deviation	28.30	26.32	17.07
Variance	801.1682	692.8744	291.385
Average deviation	22.125	21.8485	12.8548
Coefficient of Variance %	49.16183	41.94488	27.88146

Table 4.2.5. One tailed test for preference for the mother on Trial 1, Trial 2 and on the Combined Trials

	Df	t	P. value
Trial 1	19	-1.19	NS
Trial 2	19	-2.16*	$p < 0.025$
Combined Trials	19	-2.94**	$p < 0.005$

* $p < 0.025$

** $p < 0.005$

<u>The relationship between the infant's birth weight and extent of preference for the mother</u>

A Pearson's Product-Moment Correlations was used to assess the relationship between the infant's birth weight and extent of preference for the mother's face. Again, a negative, non-significant correlation ($r = -0.13$, NS) was found.

<u>The relationship between the infant's age at testing and extent of preference for the mother</u>

The relationship between the infant's age at testing and extent of preference over the combined Trials was assessed by Pearson's Product Moment Correlations and a negative, non-significant correlation ($r = -0.13$, NS) was obtained, suggesting that preference for the mother's face decreases with increasing age.

Age Effect

A Sex (Male and Female) x Age (< 36 hours and > 36 hours) analysis of variance was carried out on the percentage fixation times on the mother on the combined Trials. Neither the main effects Age ($F(1, 16) = 0.01$, NS) and Sex ($F(1, 16) = 0.21$, NS), nor the Sex x Age interaction ($F(1, 16) = 0.027$, NS) were significant, indicating that younger babies (< 36 hours) and older babies (> 36 Hours) fixated their mother equally (see the means Table 4.2.6). Younger male infants ($M = 59.2$) and older males ($M = 59.6$) demonstrated equal visual fixation times. The Anova table is presented in Table 4.2.7.

Table 4.2.6 Mean preference for the mother across Sex (Male, Female) and Age Groups (< 36 hours, > 36 hours)

	Age Groups		
	< 36 hrs	> 36 hrs	Average
Male	59.2	59.6	59.4
	(n = 4)	(n = 6)	
Female	64.5	62.1	63.0
	(n = 4)	(n = 6)	
Average	61.8	60.8	

Table 4.2.7. Two-way Anova for fixation times for the mother across Sex (Male, Female) and Age Groups (< 36 hrs, > 36 hrs)

Source	Sum of Squares	DF	Mean Squares	F. Ratio	P. Values
Sex	73.139	1	73.139	0.214	NS
Age Groups	4.709	1	4.709	0.013	NS
Sex x Age Groups Interaction	9.294	1	9.294	0.027	NS
Sex x Age Groups x Subj. Error	5456.61	16	341.038		

Birth order effect

To determine whether preference for the mother was affected by the birth order of the subject, a two-way analysis of variance was performed on the percentage fixation times to the mother, considering two between subjects variables - Sex (Male and Female), and Birth Order (First-born and Non-first born). Neither Birth Order ($F(1,16) = 0.19$, NS), Sex ($F(1,16) = 0.35$, NS) effects, nor the Sex Birth Order interaction ($F(1, 16) = 0,09$, NS) were significant. The means (Table 4.2.8) show that overall there was no difference between first and non-first born neonates in their preference for their mother's face. But male first-borns ($M = 60.8\%$) tended to fixate their mother's face more than non-first born babies did ($M = 53.8\%$). Table 4.2.9 show the Anova summary table.

Table 4.2.8. Mean percentage preference for the mother for male and female First- and Non-first born neonates

	First Born	Non-first Born	Average
Male	60.8	53.8	59.4
	(n = 8)	(n = 2)	
Female	63.5	62.3	63.0
	(n = 6)	(n = 4)	
Average	61.9	59.5	

Table 4.2.9. Two-way Anova for preference for the mother across Sex and Birth Order

Source	Sum of Squares	DF	Mean Squares	F. Ratio	P. Values
Sex	119.885	1	119.885	0.355	NS
Birth Order	65.039	1	65.039	0.193	NS
Sex x Birth Order	31.135	1	31.135	0.092	NS
Sex x Birth Order x Subj. Error	5389.16	16	336.822		

Number of fixations for the two faces across Trials

To examine whether neonates did fixate the two faces equally over the two Trials, a two-way Anova was computed using the number of fixations for the two faces. These were one between subjects variable - Sex (Male and Female) and one within subjects variable - Trials (Trial 1 and Trial 2). Neither Sex ($F(1, 18) = 0.19$, NS) nor Trials effects ($F(1, 18) = 0.94$, NS) were significant. The interaction of Sex x Trials led to a non-significant effect ($F(1, 18) = 0.17$, NS), indicating that both the male and the female babies' number of fixations did not differ across the two Trials. Table 4.2.10 and 4.2.11 show these data.

Table 4.2.10 Mean number of fixations for the two faces across Sex (Male, Female) and Trials (Trial 1, Trial 2)

		Trial 1	Trial 2	Average
Sex	Male	8.1	8.7	8.4
	Female	6.9	8.4	7.6
	Average	7.5	8.5	

Table 4.2.11. Number of fixations for the two faces across Sex (Male, Female), and Trials (Trial 1, Trial 2)

Source	Sum of Squares	DF	Mean Squares	F. Ratio	P. Values
Sex	5.6250	1	5.6250	0.1990	NS
Sex x Subj. Error	503.8500	18	28.2694		
Trials	11.0250	1	11.0250	0.9475	NS
Sex x Trials	2.0250	1	2.0250	0.1740	NS
Sex x Trials x Subj. Error	209.4500	18	11.6361		

Number of changes in fixation between the two stimulus faces

To investigate whether babies changed their fixation in the direction of the stimulus figures, a two-way analysis of variance was computed with one between subjects variable - Sex (Male and Female) and one within subjects variable - Trials (Trial 1 and Trial 2). The data were the number of changes in fixations between the two faces. None of the variables attained significance, indicating that there was no difference in the number of changes in fixations between the faces across Trials ($F(F, 18) = 1.55$, NS), nor was there an obvious Sex effect ($F(1, 18) = 3.44$, NS). The Sex x Trials interaction ($F(1, 18) = 2.03$, NS) was also not significant. The means (see Table 4.2.12) show that, while male babies changed their fixations between the two faces on Trial 2 ($M = 4.4$) more than on Trial 1 ($M = 2.9$), the females' number of changes in fixations between the two faces was constant over the two Trials. Table 4.2.13 presents the Anova summary table.

Table 4.2.12. Mean number of changes in fixations between the two faces across Sex and Trials

		Trial 1	Trial 2	Average
Sex	Male	2.9	4.4	3.6
	Female	2.3	2.2	2.2
	Average	2.6	3.3	

Table 4.2.13. Number of changes in fixations between the two faces across Sex and Trials

Source	Sum of Squares	DF	Mean Squares	F. Ratio	P. Values
Sex	19.6000	1	19.6000	3.4487	0.074980
Sex x Subj. Error	102.3000	18	5.6833		
Trials	4.9000	1	4.9000	1.5556	0.225593
Sex x Trials	6.4000	1	6.4000	2.0317	0.166889
Sex x Trials x Subj. Error	56.7000	18	3.1500		

Comparability of the results across observers

To determine whether there was bias on the part of the observer recording the neonates' visual fixations, a two-way analysis of variance was performed using percentage preference for the mother. The two between subject variables were Sex (Male and Female) and Conditions (Not Blind and Blind). Since the previous experiments of this thesis have indicated sex differences, there is a possibility that the observer (author) might have biased the data as a function of the sex of the infant. For this reason sex was included as a factor in this analysis. None of the variables was significant indicating that there was no difference across conditions ($F(1,16) = 0.04$, NS), nor was there a sex effect ($F(1, 176) = 0.19$, NS).

Thus, the observer seems not to have biased the data at least in this experiment. The Sex x Conditions interaction F(F1,16) = 0.03, NS) was also not significant, suggesting that the observer did not bias the data in favour of one sex in the "not blind" condition. Inspection of the means set out in Table 4.2.14 shows no significant difference in preference for the mother when the observer knew or did not know the identity of the mother. The small non-significant difference indicating a small bias could be expected. The Anova summary table is illustrated in Table 4.2.15.

Table 4.2.14. Mean percentage preference for the mother for Males and Females across conditions

		Not Blind	Blind	Average
Sex	Male	61.1	57.7	59.4
	Female	63.1	62.9	63.0
	Average	62.1	60.3	

Table 4.2.15. Preference for the mother across Sex and Conditions

Source	Sum of Squares	DF	Mean Squares	F. Ratio	P. Values
Sex	65.7031	1	65.7031	0.1932	NS
Conditions	15.9668	1	15.9668	0.0469	NS
Sex x Conditions	12.3403	1	12.3403	0.0363	NS
Sex x Conditions x Error	5442.3045	16	340.1440		

Preference for the mother on each of these two conditions (Blind and Not Blind) was further examined using correlated t-tests. While neonates demonstrated a preference for their mother's face over the stranger's face ($t=-2.64$, $df=9$, $p<0.025$, one-tailed) on the Blind condition, the difference in the amount of fixations paid to the mother and stranger was not significant on Not Blind condition ($t=-1.78$, $df=9$, ns, one-tailed).

Mother's face discrimination

Finally, since experiments 2.1, 4.1 and 4.2 tested small samples of subjects and used the same methodology and apparatus, it was felt profitable to combine the data and examine early face discrimination in a larger sample. Correlated t-tests ~~was~~ WERE computed comparing the percentage fixation times to the mother with that to the stranger on both Trials combined. There was a high significant preference for the mother ($t = -6.55$, $df = 63$, $p < 0.0005$, one-tailed). Table 4.2.16 shows this difference. Furthermore, the relationship between the age of the subject at testing and the extent of preference over the combined Trials was assessed by Pearson's Product-Moment Correlations and a positive non-significant correlation ($r = 0.07$, $df = 62$, NS) was found.

Table 4.2.16. Preference for the mother

Df	t	P.value
63	-6.55*	$p < 0.0005$

* $p < 0.0005$

To examine whether there was a difference in fixation times to the mother between younger and older babies, a two-way Anova was computed with two between subjects variables - Sex (Male and Female) and Age group (< 36 hrs and > 36 hrs). The main effect of Age group ($F(1, 60) = 0.42$, NS) was not significant, while both Sex ($F(1, 60) = 3.30$,NS) and the Sex x Age group interaction ($F(1, 60) = 2.29$,NS) failed to reach significance, though females of both age groups showed less preference for their mother than males did particularly younger ones (< 36 hrs). Tables 4.2. 17 and 4.2. 18

Table 4.2. 17 Mean percentage fixation times for Age group x Sex for 3 experiments.

		Age Group		
		< 36 hrs	> 36 hrs	Average
Sex	Male	72.9 (n = 14)	68.5 (n = 18)	70.4
	Female	55.6 (n = 11)	66.9 (n = 39)	63.0
	Average	65.3	67.6	

Table 4.2.18. Preference for the mother across Sex and Age Group

Source	Sum of Squares	DF	Mean Squares	F. Ratio	P. Values
Sex	1343.084	1	1343.084	3.303	NS
Age Group	173.232	1	173.232	0.426	NS
Sex x Age x Group	933.804	1	933.804	2.296	
Sex x Age Group x Subj. Error	24397.457	60	406.624		

Since experiments 2.1 and 4.1 reported a tendency for males to fixate the mother more than females with the difference reaching significance in Experiment 2.1, it was decided to re-examine any potential sex effect on the exent of preference for the mother in a larger sample (n = 64) using a between-group t-test. There was no significant difference between the two sexes in their fixation times (t = 1.46, df = 62, NS), though male neonates demonstrated a slightly stronger preference for the mother's face. Tables 4.2.19 and 4.2.20 show this difference.

Table 4.2.19. Preference for the mother for male and female neonates

Mean	70.5	63.0
Standard deviation	18.99	21.45
Variance	360.807	460.267
Sum of Squares	170000.463	141438.861
Standard Error	3.358	3.793

Table 4.2.20. Sex effect in the extent of preference for the mother

SE(Diff)	Df	t	P.value
5.065	62	1.46	NS

Discussion

The present results indicated that newborns are able to discriminate between the mother's face and that of a female stranger even when controls for olfactory information and over exprimenter bias were achieved. Further, newborn babies seem not only capable of recognizing their mother but are also able to make finer visual discriminations such as the differentiation between the faces of two female adults closely matched for hair colour, hair length, and facial complexion colour.

The current findings thus confirmed the previous results of this research that face discrimination is possible within the first day of birth and that preference for the mother does not increase with age. Apparently, preference for the mother develops in the first few hours of life. The non-significant difference between younger (< 36 hours) and older babies (≥ 36 hours) seems to support this suggestion.

The extent of preference for the mother's face did also not increase with the birth weight of the neonate. Heavier babies did not demonstrate more preference for the mother than lighter babies. Nor was there a birth order effect in the extent of preference. Though first born babies, particularly males, tended to fixate their mother's face longer than non-first borns did, the difference was not sufficiently large to reach significance.

The results of this experiment appear to support the hypothesis set out at the beginning of this chapter that newborn babies may use both visual and olfactory information in discriminating their mother's face but the absence of the olfactory cues should not prevent early face discrimination.

Evidence suggesting the capacity to discriminate on the basis of olfactory information come from studies which tested older infants and which presented olfactory stimuli at 1 - 2 cm from the infant's nostrils (MacFarlane, 1975; Cernoch and Porter, 1985) or from research in which when the subjects oriented their head, their nose came into contact with the pad impregnated with the milk of the mother (Schaal et al., 1980). Since in the present research the subjects were very young (from 12 hours of age) and the faces were 30 cm away from the neonate; and the infant was facing the two faces not the breast regions which was covered with a draped sheet and presented behind a second thick sheet, the olfactory stimulus strength may have been reduced. Thus, even if the olfactory mask was not efficient, the neonate was quite far from the stimulus figures and this should discount the possibility that the neonates might have detected their mother's odours.

The non-significant difference between breast- and bottle-fed infants in the extent of preference for the mother also supports the efficacy of the olfactory mask and suggests that olfatory information may not be playing a significant role in early face discrimination. Before making such a suggestion a study which discards visual information and any discrimination would be on the basis of olfactory cues is required to clarify which of the two information, visual or olfactory, is necessary for face discrimination to occur.

In the case of the availability of both visual and olfactory information, the neonate may use only visual in the first instance. The processing of visual information may be more rapid than that of olfactotry information. The neonate may take longer to inhale odours of the breast region. Contrary to chemical odorants which sometimes irritate the olfactory and trigeminal nerves or contain alcohol which make them more volatile and elicit more and faster responses, the odours of the breast milk are not strong. They can be smelt only at a close distance and need a longer time to be processed and recognized.

Although, visual cues appear to be important in early face discrimination, it is not yet known what visual information is used by a newly born infant to discriminate between two faces. The finding that neonates could discriminate between two faces closely matched in terms of hair and complexion colour and hair length suggests either that such facial aspects are not important or that the neonates are so sensitive that they could detect the smallest and finest details of the comparison faces which, of course, were not identical. But if the neonates possess such a capacity, they should also be able to recognize some salient aspects of the mother's face from the internal features or the external aspects, such as the chin and hairline which Maurer and Salapatek (1976) reported to be discriminated by 1 month olds.

Evidence supporting the suggestion that infants process visual information rapidly comes from the number of fixations from the two stimulus faces. The infants looked many times at the faces as if they were comparing the two faces. The mother's face was fixated and therefore discriminated wherever it was presented, on the right or on the left. Thus, the neonates did not prefer one side to another, rather they looked more at the side where their mother was shown. This finding indicated no significant general preference for a given side, nor was there any association between sex and side preference. Some neonates fixated their mother just once or a few times for considerable longer time, others looked many times but for short periods.

The fact that neonates changed the direction of their fixation between the two faces equally indicates that the two faces were sampled but the infants preferred their mothers face to the stranger's. This result gives strong support to early face discrimination as measured by fixation times.

That preference for the mother was obtained even when a blind observer was used to record the neonates' fixations and a different female stranger with similar hair colour, hair length and facial complexion to the mother was used for each subject, indicates that the results of the previous experiment were neither biased by the observer nor were they influenced by certain physical characteristics of a strange female.

The limitations of the previous experiments of this research were therefore overcome in this study, as the reliability of the observer was confirmed. These successful results provide a strong support to the finding of early face discrimination.

Contrary to the previous findings reported earlier in this thesis, the current results show no significant difference between male and female neonates in preference for the mother's face. However, when the data of the three experiments were combined and analysed, a non-significant difference between the two sexes was found, though male neonates demonstrated slightly stronger preference for their mother's face than females did. This result suggests that the sex effect found earlier in this thesis in a small sample could have been due to chance. It could be however, that females learned the mother's face earlier and started to show a novelty effect.

Conclusion

This experiment provided further evidence to support the finding of early face discrimination. Neonates from 12 hours to 4 days of age were capable of recognizing their mother's face and demonstrating preference for the mother even when control for olfactory information was achieved.

The use of a blind observer and a baby-holder and one female stranger for each subject provided more validity to the neonates preferential visual behaviour.

The close matching of the mother and stranger faces for facial brightness discarded the possibility that the neonate may be utilising such featural aspects in order to recognize the mother. The neonates could perhaps be using other information such as the information about the high contour density in the top part of the face. Evidence suggests that even neonates are sensitive to a range of spatial frequencies. They prefer patterns whose filtered amplitudes are greatest. Kleiner (1987) reported preferences in babies for stimulus energy as indexed by amplitude spectrum (which represents the amplitudes (contrasts and orientations of the sinewave components).

The next question to be answered is: can the neonate recognize the mother's face under these test condition using only olfactory information?

Experiment 4.3

Mother versus parturient lactating female stranger: Absence of visual information

Introduction

In the two previous experiments neonates could recognise their mother's face even when rigorous controls for olfactory information were implemented. In the present experiment, in contrast, visual information was discarded, while olfactory cues were available to the infants, so any discrimination of the mother's face would be on the basis of olfactory information.

Aim

To test the hypothesis that visual information is necessary for early face discrimination and it's absence would prevent face discrimination. Furthermore, this experiment examined whether neonates can detect their mother's odours under the present experimental conditions. Also, because this is a control study for previous ones and as such, it requires the same design.

Since evidence suggests that the axillary odours of lactating mother were discriminated by their 2 week-old infants, as opposed to the non breast feeding mother's axillary odours (Cernoch and Porter, 1985), it was decided to use a parturient lactating female stranger for each subject and include both a group of breast fed, and a group of bottle fed neonates, in this experiment. Each subject was shown the faces of two parturient lactating females but each had her own odours including those of perfumes and make-up.

Research in to olfactory perception in neonates has reported contradictory results about sex effect. In Balogh and Porter's (1986) study females demonstrated preferential orientation to the exposure odour when males showed right turning bias regardless of odour position. However, only males responded to artificial odours when respirometer recording was used to measure olfactory sensitivity in Self et al's (1972) research. Since the analysis of the combined data of the three previous experiments indicated that male neonates fixated their mother's face longer than females did, it was seen useful to include sex as a factor in the present study and compare the capacity of male and female neonates in discriminating their mother through olfactory cues.

Method

Subjects

The subjects were 24 healthy and apparently normal infants, as indicated by their Apgar scores after birth (Mean Apgar score at 1 min was 7.58, sd = 2.06; at 5 min was 9.46, sd = 0.99) from the Royal Maternity Hospital, Glasgow, tested as they became available with respect to hospital routine. Their mean age was 46.44 hours, sd =32.18 (range 5.09 - 124.25 hours). The difference between males and females in age was not significant by t-test (t = -0.78, df = 22, NS). The mean birth weight of the group was 3.39 Kg, sd = 0.47, (range 2.78 - 4.85 Kg). Also, the differnce between male and female neonates in birth weight was not significant by t-test (t = 0.83, df = 22, NS). Table 4.3.1 shows the subjects' sex, age, birth-weight and Apgar scores.

Table 4.3.1 Subjects' sex, age, birth weight and Apgar scores (N=24)

Ss	Sex	Age (hrs)	Birth weight (kg.)	Apgar at: 1min	5mins
1	M	5.09	3.32	9	10
2	M	8.17	3.35	6	10
3	M	18.30	3.66	8	10
4	M	28.40	3.27	8	9
5	M	32.00	3.75	8	9
6	M	36.50	3.46	5	9
7	M	38.55	4.13	8	9
8	M	39.33	3.43	7	10
9	M	48.00	3.53	9	10
10	M	56.30	2.82	9	10
11	M	58.52	3.16	8	10
12	M	124.25	3.96	9	10
13	F	4.48	2.90	9	10
14	F	24.30	3.23	7	9
15	F	24.36	2.88	9	10
16	F	25.32	3.45	9	10
17	F	38.30	2.78	9	10
18	F	40.30	2.96	8	10
19	F	48.00	3.38	8	10
20	F	48.41	2.96	8	10
21	F	64.50	3.11	8	10
22	F	72.10	4.04	9	10
23	F	113.00	4.85	9	10
24	F	118.11	3.16	7	9
Mean		46.44	3.39	7.58	9.46
Sd		32.18	0.47	2.06	0.99

Of the 24 subjects, the birth method of 18 was normal (SVD), 3 were sectioned (LUSCS) and 3 were forceps delivery (MCFD). Experiment 2.1. (Chapter 2) presents the explanation of these terms.

A further 3 neonates were tested but excluded from the sample because of side bias in their looking behaviour.

In the final sample both sexes and method of feeding (breast and bottle) were equally represented.

Stimuli/apparatus

These were the live faces of the mother, and a strange parturient, lactating female matched for overall brightness, hair colour and hair length. The faces were presented as in the previous experiments (behind a screen) but the apertures were covered with an open-weave gauze. This material was chosen because the olfactory information could pass through and had a minimum effect on air flow, but obscured details of the faces. The lighting provided by the two fluorescent tubes above and in front of the faces prevented the transmission of visual information. A small hole was made into the screen to observe the visual behaviour of the neonate. Apart from this, the apparatus was the same as in the previous experiments (see Figure 4.3.1 photograph of the apparatus.

FIGURE 4.3.1 Photograph of the apparatus

Procedure

In all respects the same method and procedure were adopted as in the previous experiments with the exception that the olfactory mask was removed. Another display screen was used, as the one employed in the precedent experiment still contained the air fresher odour.

The subjects were tested in the same hospital, at the same time of day. The mother and stranger were instructed, as in the previous studies, not to smile or make facial expressions, as the baby could still see them through the cloth. Though believed, it was not true. Actually, the mother and the stranger were able to see the subject clearly but the infant could not because of the direction of the lighting.

Results

The fixation times were expressed into percentages prior to analysis. The data are presented in Table A below. Figure 4.3.2 illustrates preferences for the mother and the stranger. In this study analysis of data would concentrate only on critical fixation data.

Table A **Percentage fixation times (in seconds) for the mother and the stranger**

Trial 1 Stranger	Trial 1 Mother	Trial 2 Stranger	Trial 2 Mother	Combined Trials Stranger	Combined Trials Mother
Male					
7.80	92.20	46.75	53.25	27.25	72.75
1.15	98.85	36.50	63.50	18.75	81.25
94.50	5.50	41.50	58.50	67.75	32.25
30.75	69.25	58.50	41.50	44.75	55.25
71.50	28.50	67.50	32.50	69.75	30.25
20.25	79.75	71.00	29.00	45.75	54.25
97.50	2.50	93.00	7.00	95.22	4.78
73.50	26.50	100.00	0.00	86.75	13.25
80.00	20.00	12.00	88.00	46.00	54.00
76.00	24.00	67.50	32.50	71.50	28.50
34.00	66.00	72.50	27.50	53.25	46.75
0.00	100.00	31.00	69.00	15.20	84.50
Female					
41.50	58.50	36.00	64.00	38.75	61.25
72.00	28.00	73.50	26.50	72.75	27.25
16.50	83.50	51.50	48.50	34.25	65.75
100.00	0.00	74.95	25.05	87.50	12.50
7.00	93.00	78.50	21.50	42.75	57.25
69.50	30.50	69.00	31.00	69.50	30.50
21.00	79.00	89.50	10.50	55.25	44.75
97.00	3.00	39.50	60.50	68.25	31.75
11.50	88.50	43.50	56.50	27.50	72.50
55.50	44.50	73.50	26.50	64.50	35.50
24.00	76.00	76.50	23.50	50.50	49.50
3.90	96.10	20.50	79.50	12.25	87.75

Table 4.3.2 Mean percentage preference for the mother's face across Sex, Method of Feeding and Trials

		Trial 1	Trial 2	Average
	Breast	62.3	46.4	
Male				46.5
	Bottle	39.8	37.3	
	Breast	48.9	36.1	
Female				48.1
	Bottle	64.5	42.8	
Average Trials		53.9	40.6	
Average Breast		48.5		
Average Bottle		46.1		

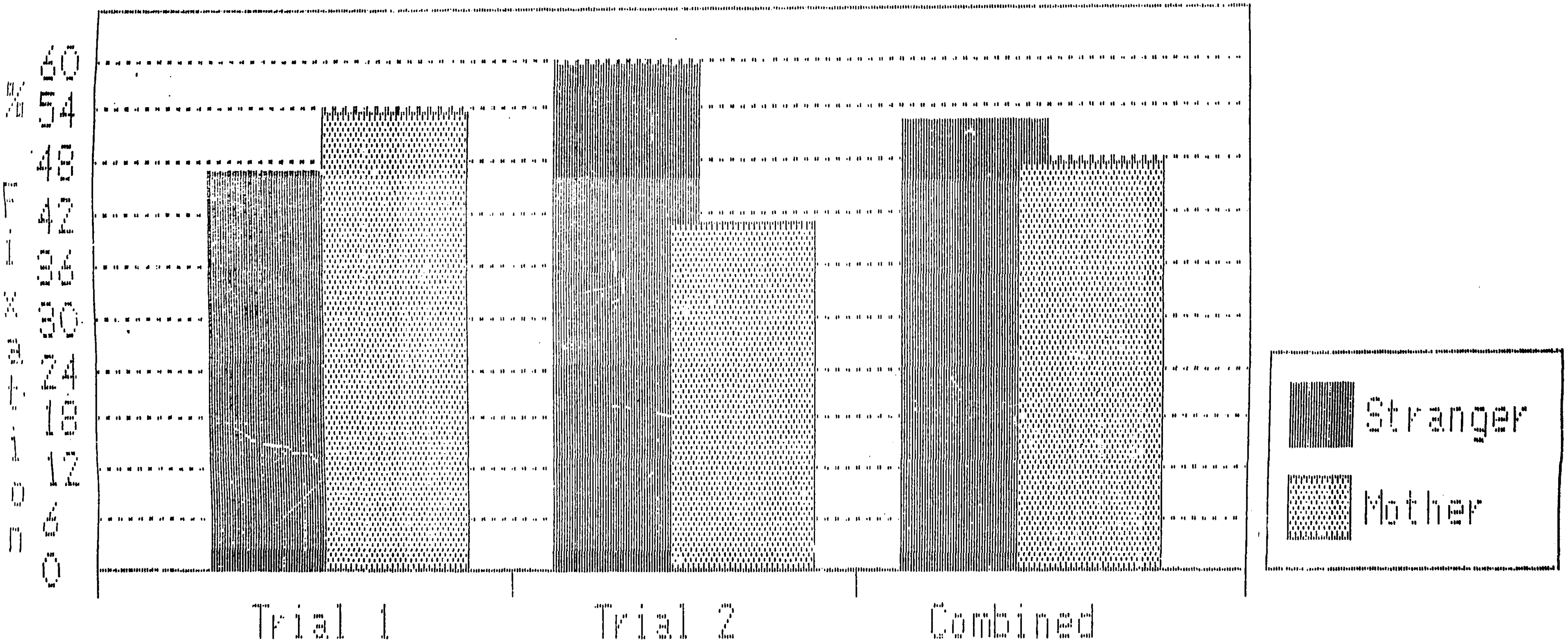


Figure 4.3.2 Percentage preference for the mother and the stranger across trials.

Preference for the mother across Sex, Method of Feeding and trials

An initial three-way Anova was performed on percentage preference for the mother, using two between subjects variables -Sex (Male and Female) and Method of Feeding (Breast and Bottle) and one within subjects variable - Trials (Trial 1 and Trial 2). No main effects of Sex ($F_{(1, 20)} = 0.028$, NS), and Trials ($F_{(1, 20)} = 2.73$, NS), or interactions of Sex and Method of Feeding ($F_{(1, 20)} = 1.93$, NS), Sex and Trials ($F_{(1, 20)} = 0.25$, NS). Method of feeding and Trials ($F_{(1, 20)} = 0.020$, NS) and Sex, Method of Feeding and Trials ($F_{(1, 20)} = 0.48$, NS) approached statistical significance. There was neither a preference for the mother across Trials nor was there a Sex effect in looking time for the mother. Similarly, the method of feeding had no effect on preference for the mother's face. The means and Anova summary table are presented in Table 4.3.2 and 4.3.3.

Table 4.3.3 Three-way Anova for preference for the mother across Sex, Method of Feeding and Trials

Source	Sum of Squares	DF	Mean Squares	F. Ratio	P. Values
Sex	31.4442	1	31.4442	0.0280	NS
Method of Feeding	63.5950	1	63.5950	0.0565	NS
Sex x Method of Feeding	2178.2339	1	2178.2339	1.9365	0.175176
Sex x Method of Feeding x Subj. Error	22496.1394	20	1124.8070		
Trials	2104.7629	1	2104.7629	2.7334	0.108810
Sex x Trials	193.0014	1	193.0014	0.2506	NS
Method of Feeding x Trials	15.9276	1	15.9276	0.0207	NS
Sex x Method of Feeding x Trials	373.8041	1	373.8041	0.4855	NS
Sex x Method of Feeding x Trials x Subj. error	15400.0853	20	770.0043		

To determine the extent of any preference for the mother, correlated t-tests were used to compare the fixation to the mother with that to the stranger on Trial 1, Trial 2 and on both Trials combined. The difference on Trial 1 ($t = -0.54$, $df = 23$, NS) and on both Trials combined ($t = 0.57$, $df = 23$, NS) was not significant, although it was found to be so on Trial 2 ($t = 1.97$, $df = 23$, $p < 0.05$, one-tailed) with neonates showing preference for the direction of the stranger's face. Preferences for the mother are collapsed into means in Table 4.3.4. The t-values are listed in Table 4.3.5.

Table 4.3.4 Mean percentage preference for the mother on Trial 1, Trial 2 and on the Combined Trials

	Trial 1 %	Trial 2 %	Combined Trials %
Mean	53.9	40.7	47.3
Standard deviation	35.14678	23.16333	23.19267
Variance	1235.296	536.5397	537.9
Average deviation	31.66024	19.62569	19.08208
Coefficient of Variance %	65.20486	56.97063	49.08372

Table 4.3.5. t-tests for preference for the mother

	Df	t	P.value
Trial 1	23	-0.54	NS
Trial 2	23	1.97*	$p < 0.05$
Combined Trials	23	0.57	NS

$p < 0.05$

The relationship between the infant's age at testing and extent of preference for the mother

A further Pearson's Product-Moment Correlations was used to assess the relationship between the age at testing and extent of preference over the combined Trials. A negative, non-significant correlation ($r = -0.063$, NS) was obtained.

Discussion

The aim of this experiment was to test the hypothesis that visual information is necessary for early face recognition to occur and its absence would prevent such discrimination. The present results confirm this assumption and answer the main question that early face discrimination is possible but only when visual cues are available. Furthermore, the present findings demonstrated that under the same experimental conditions as in the previous experiments, olfactory information was not sufficient to evoke preferential behaviour towards the mother. When prevented from seeing their mother, the neonates failed to identify and make successful discriminations on the basis of oflactory information. It follows that early recognition of the mother's face in the previous experiments was based on visual rather than on olfactory information.

It should be noted however that though neonates can perceive and discriminate between artificial olfactory stimuli presented at 1-2 centimeters when visual information is unavailable (Engen et al., 1963; Lipsitt et al., 1963; Engen & Lipsitt, 1965; self et al., 1972; Sarnat, 1978), they failed to recognise the odour of the breast-milk of their mother in Russell's (1976) study adopting the same distance. This finding is in accord with the present results, although in the current experiment the faces were deliberately shown at 30 cm, the normal viewing distance for visual preference study information. It is possible that if the distance was less, neonates would be able to detect their mother's odours. Perhaps if tne neonates were hungry they woud be more sensitive to their mothers' odours. In any case the maternal odours are weaker than the artificial odorants which irritate the trigeminal nerve and immediately elicit the infant's response.

The successful results obtained from the current experiment do not only confirm the previous suggestions made in Chapter 2 and earlier on in this chapter that early face recognition is mediated by visual processing systems when faces are at 30 cm from the neonate's but they also support the efficacy of the olfactory mask used in the two preceding experiments. Further they explain the non-significant difference between breast and bottle-fed subjects in responding to their mother's face.

Though it is now clear that under such conditions of testing, early face discrimination is predicated upon vision, it is still not known which facial features the neonate learns and utilizes to recognize the mother's face from the stranger's. The success of the previous and present experiments must indicate that neonates are capable of processing visual information and storing it for later use. However evidence from the contrast sensitivity studies suggests that under 2-3 months infants have poor acuity, contrast sensitivity and respond only to the amplitude of spatial frequency components not to their spatial phase. In other words at this age quantitative discrimination is possible but not qualitative such as discrimination of pattern information (Atkinson et al., 1979). The qualitative change occurs between 1 and 2 months of age.

As far as sex and method of feeding are concerned, not much can be said since the newborn subjects initially failed to show preference for their mother's face. They appeared to look at random, fixating one face then another. The faces received almost equal fixations except on Trial 2 where the amount of looking time was slightly greater for the stranger than for the mother.

Even though the stimulus faces were behind the gauze patches and the neonates did not have a stimulus or stimuli to concentrate on their fixations, they looked at both gauze patches during the two trials. In some cases, infants turned their head more in one direction then the other.

Conclusion

The neonates failure to discriminate their mother's face from that of a parturient, lactating female stranger through olfactory information indicates that under the present conditions of testing visual information is necessary for early face discrimination and recognition to occur.

These findings do not, however, contradict previous evidence suggesting the 4 day-olds' capacity to make successful discrimination between their own mother and another mother on the basis of smell, when presented at 1-2 centimeters distance. The distance at which faces were shown in the current research, the age of the sample used (5 hours-124 hours of age) and the procedure used might have accounted for the results obtained. Whether or not there were shortcomings in the experimental methods adopted in testing the hypothesis that the absence of visual information prevents face discrimination, the present results do confirm the findings of the earlier experiments that olfactory information does not play an important part in early face discrimination. Further, they suggest that early face recognition was mediated by visual processing systems when testing at 30 cm.

What visual information the neonate is able to pick up and at which period during the first 24 hours would be interesting to explore. A study monitoring the total awake-time spent in face-to-face interaction with the mother in order to assess the real time exposure to the mother's face is required to further elucidate this discrimination process.

Experiment (4.4) investigating whether the mothers attract their infant's attention during testing

Introduction

The last series of experiments revealed the importance of visual information over olfactory cues in early face recognition. However it is still not known whether the neonates from 12 hours of age prefer the face of their mother to the face of a female stranger because they recognize some visual aspects of it or because the mothers attempt to capture their infant's attention during the testing. Since infants and mothers could see each other during testing, the mother could have attracted the infant's attention, though they were requested not to do so. However, since the faces were observed by a second observer who made sure that the two faces maintain neutral expressions throughout the testing, and reported no such behaviour on the part of the mothers, it was hypothesized that mothers did not attempt to attract their infant's attention. In the event that they did, the use of adult naive subjects in the present experiment to judge which of the female faces belonged to the mothers should clarify this point.

To test this hypothesis a group of subjects blind as to the identity of both the mother and the stranger were asked to view videotapes of mother's and stranger's faces as 20 infants were being tested and identify which of the two faces was that of the mother in each trial.

Before describing this study (4.4) it is necessary to provide some brief details about Experiment 4.2 in which the infants' visual behaviour was recorded.

<u>Subjects</u>

The same subjects as used in Experiment 4.2. These were all full-term Caucasian neonates from Glasgow's Royal Maternity Hospital. They were 20 (10 male and 10 female), (see Exp. 4.2 for details about subjects. Table 4.2.1 (Exp.4.2) shows the subjects' age and birth weight.

<u>Apparatus</u>

The same apparatus was used as in experiment 4.2. A video camera was utilised to record the testing.

<u>Stimuli</u>

Two live female faces (the faces of the mother of the infant and a female stranger) were presented. A different stranger was paired with each mother.

<u>Procedure</u>

The procedure was similar to that of Experiment 4.2.

Results

The results were reported earlier in Experiment 4.2. The obtained visual fixation times are set out in Table A (Exp.4.2). Preference for the mother was significant on the combined trials (t=-2.94, df=19, p,0.05, one-tailed).

Experiment 4.4

Method

Subjects

They were 20 (10 males and 10 females) volunteer students recruited on a random basis from Glasgow University. Their mean age was 20.85 years, sd=2.45 (range 18-32 years). Another three subjects were tested but excluded from the sample because they did not fully complete the questionnaire. Table 4.4.1 shows the subjects' age and sex.

Table 4.4.1 Subjects' age and sex.

Ss	Age (years)	Sex
1	19	M
2	19	M
3	19	M
4	20	M
5	20	M
6	20	M
7	19	M
8	20	M
9	21	M
10	20	M
11	20	F
12	19	F
13	32	F
14	21	F
15	29	F
16	20	F
17	18	F
18	20	F
19	19	F
20	22	F
Mean	20.85	
Sd	2.45	

M: Male
F: Female

Stimuli

The stimulus faces (the mother and a female stranger) were shown on a videotape. Twenty pairs of faces (mother/stranger) were filmed from a position above and behind the infant's head during 40 seconds fixation accumulated over two test trials, each of 20 seconds. The data gathered in the course of this experiment are presented in Table A, Exp.4.2. Not all the recordings from this experiment have been used. One was excluded due to failure to obtain complete video records the result of equipment malfunction.

The subjects could not see the infants' visual behaviour. This was done to prevent subjects being influenced by the neonates' preferential behaviour, and to allow them to see only the information that the infants saw in this experiment.

Procedure

The subjects volunteered to participate in this experiment. They were invited in groups of 4 to 5 at a time to a quiet room. They were told they would see different pairs of faces on a television screen. One of the faces would be the mother of the infant. Their task was to identify the actual mother and note their answers on a response sheet (see Appendix 4.4.1). A video was utilised to play the tape. It was stopped at the end of each presentation of the comparison faces (i.e the end of each trial) to allow the subjects to record their judgment. This procedure was followed until all 19 trials had been shown.

Results

It was hypothesized that the mothers did not attract their infant's attention in experiment 4.2. If they had done so, the adult subjects in the present experiment would have been able to identify the mothers presented on the videotape. The data is shown in Table 4.4.2.

Table 4.4.2 Correct Idendification of the mother on 19 Trials

Trials	NO. of correct Identification Males (/10)	Females (/10)	Total (/20)
1	4	3	7
2	9	10	19
3	4	3	7
4	7	2	9
5	1	3	4
6	5	6	11
7	8	9	17
8	10	10	20
9	4	3	7
10	2	1	3
11	8	9	17
12	6	7	13
13	8	6	14
14	10	9	19
15	10	10	20
16	9	7	16
17	6	3	9
18	1	0	1
19	3	4	7

Over 19 Trials, the number of correct identifications of the mother was only slightly more common than the number of misidentifications (10 vs 9). The difference between the frequencies of correct and incorrect identification of the mother was not significant by a binomial test

(p=0.676, N=19, X=10). This suggests that the subjects were operating at a chance level.

To find out whether male and female subjects differed in their judgments, a Mann-Whitney test was computed. Male and female subjects did not significantly differ from each other in their decisions (U=163.0, Z=-0.511). Table 4.4.3 shows the means.

Table 4.4.3 Mean number of correct and incorrect identification on 19 Trials by male and female subjects

		Mothers Correctly identified	Mothers Incorrectly identified
Subjects	Males	11	8
	Females	10	9

Discussion

From the above data it appears that overall, mothers did not attempt to attract their infant's attention. The failure of the naive adult subjects in this experiment to detect the actual mothers provides support for the hypothesis that mothers did not attract their infant's attention.

The results indicate that, as a group, the subjects' judgments lacked accuracy. Nevertheless, there was no obvious sex effect on the subjects' decision making.

The findings of the present experiment suggest that the decision was based on the amount of interest displayed by the female faces. This information seemed to be coming from the static expressions exhibited rather than from dynamic aspects of the faces. The subjects noted that in a few cases there was some level of facial movement such as fast blink rates in both the faces of the mother and the stranger. It follows that even if the newborn babies used such information the dynamic level displayed on the stimulus faces was not specific to the mother. Thus, it is unlikely that neonates were basing their early recognition on the dynamic information in the mother face's. This suggestion is supported in part by Bruce and Valentine's (1987) findings that even adults show a limited ability to identify familiar faces from dynamic point-light displays which maintain rigid and expressive motion.

To conclude, the findings of this experiment give strong support to the proposition that newborn babies are capable of rapidly learning some visual aspects of the mother's face. This information however seems to be of a static rather than dynamic nature, although it is still possible that dynamic information may be potentially available and used in normal interaction.

Conclusion

The data from this experiment has successfully demonstrated that, though the mothers and neonates see each other during the testing, the mothers as a group do not seem to attract their infant's attention under the present experimental conditions. The use of naive adult subjects confirms the obtained results. Preference for the mother's face does not appear to be governed by general attention-capturing characteristics exhibited by mothers. Neonates seem to learn some static visual features rather than dynamic properties of the mother's face. In any case such information may be too abstract for a newborn baby.

There is some slight possibility that maternal recruitment of attention may be linked to time-locked, and very subtle facial movements, to which neonates are 'supersensitive'. This could not be tested by the present paradigm and must await further investigation at a macrolevel.

General Discussion

The aim of the first three experiments was to test the hypothesis that emerged from Experiment 2.1 concerning the effect of olfactory information on early face discrimination. Although the data confirm and replicate the findings of Field et al. (1984) and those obtained in the earlier experiment of this thesis which suggest early face recognition, they do not fit with the assumptions of the two-visual system model of face perception as described in Chapter 1. The results thus demonstrated that visual information is necessary for such discrimination to occur, but the absence of olfactory information does not prevent early face discrimination, at least when tested from 30 centimeters and under the same experimental conditions as those adopted in the present research.

Early face discrimination

As mentioned above the finding of early face discrimination and recognition does not support the two-visual system model's proposition that only subcortical processing is possible in very young infants, and the neocortical networks, mediating face discrimination and recognition, are immature at birth. Bronson's model (1974, 1980) indicates that neonates should not be capable of visual discrimination based on pattern differences nor of visual memory. Face recognition is surely not possible according to this view.

Morton (1987) attributes neonates' responding to the facelike characteristics to an innate predispositional mechanism. Once attention is directed towards a face, a secondary learning mechanism is then engaged to process a particular face. This secondary system which governs the recognition of individuals, including the mother's face, develops slowly in the first months of life. According to this two visual system model, face recognition does not occur until this secondary system matures and functions.

Future research should consider the validity of a dichotomization of the developing visual system especially after the present research has discarded the possibility that neonates use olfactory or auditory information in the discrimination process, and has demonstrated that neonates of only a few days of age can process visual information and use it for discrimination and recognition.

The demonstration that neonates from 12 hours of age were able to recognize and discriminate their mother from a female stranger even when controls over facial brightness and olfactory information were implemented, replicates and extends Field et al.'s study. That this is far earlier than the age at which face discrimination has been suggested by many researchers to be possible is worth stressing. As previously described in Chapter 1, studies using both real and representational faces reported a significant difference in visual fixation between the mother's face and a stranger's face or the face of a mannequin from 1 - 2 weeks of age (Carpenter et al, 1970; Carpenter, 1973; Carpenter, 1974). Research which adopted real faces noted such discrimination between 3 - 4 weeks of age (Masi & Scott, 1983), at 5 weeks of age (Maurer & Salapatek, 1976), or by 13 weeks of age (Caldwell, 1965).

In the review chapter on face discrimination by young infants a number of methodological issues were raised which were important and might have accounted for the large discrepancy in age at which face discrimination has been demonstrated for real and representational faces. One of these was the lack of control for olfactory cues in the real face research. The results of Experiment 4.3 indicate that early face discrimination is possible even when olfactory information is unavailable but is not when visual information is absent and olfactory cues are presented at 30 centimeters away from the infant's nostrils.

The present research designed to control olfactory cues demonstrated that neonates from 12 hours of age remarkably discriminated the real face of their mother from that of a female stranger matched closely for facial brightness, even when auditory information was unavailable. These findings concluded that early face discrimination undoubtedly was mediated by visual processing systems under the present experimental conditions.

The second methodological issue raised in Chapter 1 related to the use of several strangers and to the controlling for facial brightness. The success of Experiment 4.2 demonstrated that even when facial brightness was controlled across subjects, neonates could recognize their mother's face from that of a stranger's. This finding suggests that early face discrimination cannot be attributed to simple facial features such as hair colour, hair length and colour of complexion.

The use of a stranger for each subject did not affect the results. Preference for the mother was obtained in experiments which used only two female strangers throughout, or one for each subject.

The finding that early face recognition is possible leads inevitably to the question "what information is the neonate's visual system capable of processing shortly after birth"? Since there is little evidence of face recognition in the neonatal period and as of yet no study has investigated the actual information used by a newborn infant - in early face discrimination this question cannot be answered at this stage. Field et al (1984) suggested that neonates may use some visual aspect of their mother's face. The present research supports this view. That neonates are capable of learning rapidly some facial features of their mother's face complements recent research suggesting rapid learning in the neonatal period through olfactory (MacFarlane, 1975) and auditory (DeCasper & Fifer, 1980) modalities. However it neither supported the propositions that olfactory cues might be utilized by neonates in recognizing their mother's face (Field et al. 1984) nor the suggestion that voice cues are necessary for such discrimination to occur (Masi & Scott, 1983). One explanation of such early auditory discrimination is that the neonate has a functioning auditory system in early labour (Scibetta, Rosen, Hoghberg and Chik, 1975). The human cochlea (the inner ear where the nerves necessary for hearing are to be found) is structurally fully mature at birth (Bast & Anson, 1949, Von Bekesy, 1960). Also, the neural structure needed to analyze bilateral auditory stimulation appears to be functional at birth, at least at a subcortical level (see Hecox, 1975).

Similarly, the finding of early preference for maternal odours is supported by evidence suggesting that the trigeminal nerve which mediates intranasal and intraoral irritative responses to volatile and non-volatile chemicals and skin sensations is well formed in utero

(Gasser and Hendrickx, 1969; Hogg, 1941, see Doty, 1986) and is functional at birth. Like taste, olfaction cannot begin until the nasal cavity is filled with air (Carmichael, 1954) and this first occurs during labour.

This evidence of early sensitivity of auditory and olfactory systems combined with the findings of the present research on visual discrimination supports the proposition of intermodal unity suggested by Meltzoff and Borton (1979). Neonates may be able to relate a subsequent visual perception to the stored representation of the mother's voice and odours perceived during labour. That the foetus may learn the mother's voice and odours in the antenatal period is perhaps unlikely, since the mother's voice does not sound the same in the womb as it does outside the body of the mother. Since the middle ear of the foetus is filled with fluid, its conductive property is different from postnatal life. After the birth of the infant, the tympanic membrane is largely transparent to sound, and the role of the ossicles is different. Also a 4 month-old foetus has more hair cells in the cochlea than a 9 month-old foetus. Bredburg (1968) has shown that there is a continuous gradual loss of hair cells from the mid-foetal period until old age. Even if the foetus is capable of hearing during the last 10 to 12 weeks of gestation (Rubel, 1985) the auditory sensitivity is very low. It is improbable that the foetus is capable of detecting the information-bearing frequency components of the mother's voice. Also, the odours of the mother's internal body are certainly different from the external odours (odour of the milk, skin hormones). Furthermore, the lack of air in the nasal cavity of the foetus while in utero dismisses olfactory antenatal experience (amniotic fluid movement could take the place of air movement as a carrier. Nevertheless, these are hypotheses which raise possible areas for further research.

Referring back to Meltzoff and Borton's (1979) suggestions one finds that, though they indicated the 1-month-old's ability to perceive information as invariant across the different modalities, they failed to determine the exact nature of this information.

Similarly, Butterworth (1987) suggested the capacity of an infant to encode information cross-modality. This proposition relates firstly to the presence and functioning of different sensory modalities and secondly to the process of information being crossed.

It could be argued, however, that such ability as reported in older infants is not yet developed at birth, and therefore it does not explain the findings of the present research. Certainly, different sensory systems have followed a different pattern of evolutionary development (see Sarnat & Netsky 1974), and therefore are organized differently in contemporary mammals. Since visual, olfactory, and auditory systems, are different in nature and independent from each other, they may differ in the scope of preprogrammed automatic reponses and in the loci of the neural structure mediating such responses.

The finding that the mothers were not attracting the attention of their infants in the present research and that preference for the mother was not elicited by the dynamic properties of the face, but by their static expressions, suggests that neonates may learn features of the mother's face and use this information later in the discrimination process. Evidence suggests that discrimination of the internal features of the face is not possible in the neonatal period, and that 1 month-old infants may use external features of chin and hairline to distinguish between two photographed faces (Maurer & Salapatek, 1976; Bushnell, 1982). Further research aimed at preventing neonates from seeing the internal features of the face, while preserving the external aspects (hairline), are necessary to clarify what visual information the neonate is able to pick up soon after birth.

Sex difference

The findings of a non-significant sex difference effect in the extent of preference for the mother's face in these three experiments did not confirm the early findings of this research suggesting better performance on the part of male neonates. When the data of Experiments 4.1 and 4.2 were combined with that of Experiment 2.1 to examine sex effect in a larger sample, no significant difference between males and females was found, though male neonates showed slightly stronger preference for their mother. These conflicting findings perhaps imply that there is no basic difference between the sexes in their visual behaviour. They probably reflect the amount of exposure to the mother's face. Perhaps when the sex of the baby is what the mother wished during her pregnancy, early face-to-face interaction is greater than when she is disappointed. It is possible that when the mother has a warm first contact with the baby some visual information is encoded and used afterwards.

Reliability of the observer's recordings

As far as the reliability of the data is concerned, the use of blind scoring procedures in the present chapter demonstrated that preferene for the mother was not biased by the observer. Furthermore, support for the reliability of the observer's recordings of fixations comes from the use of various blind observers of different sexes in the second and third experiments.

Videotaping the visual fixations would have provided more reliability to the data obtained. Since the present research was an individual project it was not possible to do this due to the limited personnel and to the practical difficulties that would have been involved. The infant's visual behaviour was videotaped in Experiment 4.4a (only its data was reported in Appendix 4.4a) and preference for the mother was found.

Conclusion

The aim of these experiments was to control for olfactory information to reduce its potential influence on early face discrimination, and to demonstrate that the recognition was based on visual information. Further, these experiments controlled for brightness of stimulus faces, experimenters' bias, and maternal attention-getting. The data did not demonstrate any effect of olfaction and replicated the main finding of Field et al., (1984), and of Experiment 2.1 of this thesis, but they do not accord with the predictions of the two-visual system model of face perception as described in Chapter 1.

The present results thus answered the question of whether early face recognition is possible and indicate that such discrimination is based solely on visual information. Neonates might use olfactory information as a cue to recognize their mother, but they are unable to detect the covered odours of their mother from 30 centimeters. Though the efficacy of the olfactory mask could be suspected in the first two experiments, the removal of the visual cues and the presence of olfactory information in Experiment 4.3 indicated that early face perception is mediated by visual processing systems at least under the given experimental conditions.

The actual visual information that early face discrimination is dependent on is still not determined, but the control for brightness of the faces demonstrated that it is not based solely on the external features such as hair colour and hair length.

Chapter 5

REVIEW OF THE LITERATURE ON PERCEPTION OF INVARIANCE ACROSS POSES OF THE SAME FACES BY YOUNG INFANTS

Introduction

In the last chapter where the effect of olfactory information on early face recognition was considered, it became apparent that neonates as young as a few hours could process visual information, at least with the stimulus figures and under the conditions employed. It was suggested that the neonate is capabale of learning some featural aspect of the mother's face to be able to discriminate it from that of a female stranger. However, the information learned by the neonate presumably comes from both dynamic and static features of the mother's face. Even when static expressions are displayed by the mother, there is a great deal of internal featural variation at different rates and at various levels. Thus, the ability to recognize the mother's face as a familiar stimulus when displaying a static expression suggests the existence of processing of some level of invariance across presentations and time during the neonatal period.

Discovering just how effective the neonate is in perceiving invariance in a face across certain transformations would be an interesting introduction to this question area. The present chapter therefore examines the young infants' capacity to respond to invariance in faces. Can infants detect similarities in a given face despite a change of orientation, and what is the earliest age that discrimination of invariance is possible? If young infants can perceive invariances across the various poses of a face, can these be distinguished from the same or different poses of a novel face?

To see if invariance across representations of faces is detected by young infants one needs first to review some theoretical approaches for studying the visual behaviour of the young infants.

This chapter is divided into five major parts. First, the theoretical framework for research on infant cognition is discussed. Two most appropriate approaches are described: a) Gibsons' general differentiation theory of perceptual learning and development (1969, 1979), b) Kagan's control of attention by developing schemata (1970, 1979).

The second section reviews substantive research findings in particular content area: a) Detection of invariance and changes of orientation. The third section discusses sex effect in detecting invariance and differences. The fourth and final part discusses methodological issues.

The theoretical issues discussed in this chapter relate to 1) The role of experience, 2) The role of interpretation and 3) The role of representation in infant cognition.

The role of experience

The first issue to be examined is the role of experience, and its importance. The answer to this question depends in part on the response accorded to the question regarding the extent to which perceptual sensations need interpretation. If they do not, then experience will provide an objective information or allow the infant to detect that information more accurately. The emphasis on the role of experience raises the question of what kinds of experience are crucial in producing cognitive change. While some theorists stress the importance of active motor exploration by the infant, others give importance to the role of visual observation. In the "differentiation theory" of perceptual development proposed by the Gibsons (Gibson & Gibson, 1955; Gibson 1969), the process underlying perceptual learning is considered as the detection of distinctive features and the abstraction of general characteristics of the world. It is expected that after visual experience with a certain object through differing transformations of stimulation, the infant is able to detect the invariant properties of that object. This ability is a result of an active exploration. "Learning of differential properties should be facilitated by providing examples of contrasts along a dimension so as to define and assist isolation of the critical variable property" (Gibson, 1969, p. 99). Another important type of experience involves the opportunity to experience members of a category of stimuli which share common distinctive features.

To extend Gibson's theoretical approach to the study of infants' recognition of faces, faces in their proper orientation (en face pose) constitute a class of objects having distinctive features that have been acquired through frequent exposure, but the same faces presented in another orientation (e.g. profile) constitute a class of objects in which distinctive features are less likely to have been differentiated since faces in the profile pose are seen much less often. Thus, infants, by same age, should find it easier to discriminate one face from another when the faces are in their proper orientation than to discriminate one rotated face from another rotated face. Gibsons' views are discussed below in more detail.

The role of interpretation

The second issue concerns the extent to which perceptual experience requires interpretation for it to be meaningful. This question arises when the objectivity of the infant's view of the world is considered. Two arguments are possible. First, the infant especially the neonate lives in a subjective world of sensations which necessitate reinterpretation before they can provide objective information about the world. Second, that perception supplies the newborn with valid information about the world immediately after birth. These views will become clearer when the assumptions of Piaget and Gibson are compared.

The role of representation

This issue deals with the extent to which the infant's behaviour is considered as a response to the immediate perceptual world, as opposed to a mental world based on remembered information, imagery or some kinds of representational system. While some theorists suggest that the neonate's reactions are influenced by the immediate perceptual field, others have claimed that the newborn's mental life is rich enough to represent intended or desired states of affairs and past events. If a minor role is accorded to experience, it is necessary to posit a major role for innate predispositional mechanism. However if experience is attributed an important role in the development of a representational code, the latter may be primarily based on active visual motor experience.

1. Approaches to the perception of invariance

There have been different approaches to the perception of invariance and how infants detect such invariances. The following section discusses only Gibon's and Kagan's approaches, as they appear the most appropriate for the present research. The first emphasises the infant's ability to extract information, the second suggests the capacity for representation, which guides attention and imitation from an early age. Reference to Piaget is made from time to time. Though Piaget's ideas continue to dominate research on infant cognition, they have been challenged in several ways, particularly because Piagetian theory underestimates the capacity of young infants to extract useful information about the environment.

Gibson has pointed out that it is not only the static layout of the environment which provides direct perceptible information, but information about transformations of and within that environment is also offered to the perceiver. For instance some information specifies a movement of an object, whereas other information characterises movement of a perceiver. This latter transformation is called visual "proprioception". Information about locomotion is believed to come from inside the body but Gibson's study of the available stimulation shows that visual information is also being utilised.

It follows that Gibson (1979) viewed the environment as rich in information and he made clear the implications of this position for various theoretical controversies in psychology.

1.1. Direct visual perception: J. J. Gibson and E. Gibson. The role of experience

1.1.2 The role of experience

J. J. Gibson (1955) claimed that the infant can pick up perceptual information from birth. Thus it is useful to suppose that the neonate does not simply detect cues to depth or motion but perceives depth and motion directly. This theory does not seem to leave much space for learning through experience as it does not admit that such information needs interpretation in order to provide valid evidence about the state of environment and the perceiver's relation to it. According to Gibson's view, then, the older child is unlikely to arrive at radically new conclusions about the world. However, Gibson accords an important role for learning. He assumes that the perceptual system becomes more finely tuned to the information available. This process of fine tuning functions in two ways. Firstly, with continual exposure to a set of objects belonging to the same class, the observer becomes more capable of detecting those features, which characterize that class of objects from other objects, and ultimately the features that distinguish between different members of the same class (Gibson and Gibson, 1955).

Eleanor Gibson (1969) has explained what this process of differentiation might involve for the perception of faces by infants. First, the infant may discriminate features that differentiate faces from non faces (such as eyes, mouth, an oval head, shape, etc). At this stage the infant is still unable to distinguish between individual faces. Later, the infant learns to fixate the relevant distinctive features, but still ignoring those that remain constant across faces. For example, faces differ from each other only marginally in the horizontal alignment of the eyes within the head. However, they differ from one another considerably in the length of the nose and chin etc. For E. Gibson, it is attention to the latter features which help an infant to discriminate one face from another. Attention to the former feature does not.

Further, E. Gibson (1969) described the relation between perceptual schemata and feature differentiation. The schemata for faces in general emerges as a result of the differentiation process, not before. Gibson argues that until these features that are invariant across faces, but which distinguish faces from other objects, have been isolated, it is not known what should be entered into a schemata. This view contradicts those of Kagan (1965), which are discussed later in more detail.

The second learning process described by E. Gibson regards the detection of invariants. This process consists of two types. First, an object acquires certain invariant properties through the transformations which occur in other properties. For instance, a face can be transformed in its orientation from full-face to profile though its shape will stay invariant. Second, a single class of objects will possess certain invariant features across individual members, though there exist variations in other features. The horizontal alignment of the eyes will be invariant across different and various faces, but the length of the nose will not.

The difference betwewen Piaget's account of development and that of the Gibsons' is that the latter emphasises the importance of invariants, while Piaget claims that the infant constructs the idea of invariance by acting on objects so as to transform them and then cancelling these transformations by returning to the starting point. Gibson and Gibson argue that such invariants are not intellectual constructs emerging from interacting with the environment; they can be detected in the environment. The infant is able to observe some displacement leaving the shape or existence of an object unchanged.

1.1.3 <u>The role of interpretation</u>

Gibson's approach contrasts both the traditional empirical approaches to perception and Piaget's emphasis on the need to reinterpret perceptual information in terms of constructed concepts. The Gibsons deny that interpretation of perceptual input is required. Provided the infant attends to the appropriate relations and transformations within the optic array, valid information is there present.

1.1.4 <u>The role of representation</u>

Gibson and Gibson attributed a minor role to representation. They suggested a gradual subordination of the perceived to the conceived as is quite clear in E. Gibson's (1969) book.

> "What is wrong with saying that the young child is stimulus bound, and that cognitive development is a liberation from these bonds

> by the operations of intelligence? ... For a neonate's attention does seem to be captured by a few kinds of events in its environment. But the developmental change is not one of doing without stimulus information; it is one of seeking stimulus information in a directed, systematic fashion". (E. Gibson, 1969, p. 448).

Thus, the environment affords information to an observer in a direct way. According to the Gibsons, the only difference between the neonate and the infant towards the end of the sensorimotor period is in their capacity to pick up information from the environment. In some ways, the older infant is more reactive to the information available. Therefore, the neonate and the 18 month-infant differ in such representational capacities. The Gibsons then insisted that the infant does not need to refer to such mental processes in order to gather information about the world.

1.2 Control of attention by developing schemata: Kagan

While the Gibsons were concerned with the ways in which a stimulus provides information once it is attended to, Kagan was interested in factors that govern the distribution of attention in the first place. Kagan thus studied the infant with mental structures and schemata, so as to account for the infant's tendency to choose from the available information.

Kagan argues that in the first months of life, attention is governed by the physical aspects of the stimulus itself, rather than by any stored experience with that stimulus. The infant's attention is drawn in particular to stimuli that are marked by change such as movement or the shift from light to dark as is the case in coloured stimulus. Later the infant starts developing <u>schemata</u>. Kagan defines a schema as:

> "an abstract representation of an event that retains the relations among the physical dimensions of the original experience - be it object, sound, smell, or dynamic sequence". (Kogan, 1979, p. 164).

These internal representations of previous perceptual encounters alter the infant's distribution of attention.

> the child's attention tends to be prolonged to those events that are a little different - but not extremely different - from the one that created the original schema. Thus a 4- month-old infant with a schema for its parents' faces will look a long time at a picture or a sculpture of a face in which the eyes are arranged vertically rather than horizontally. But infants will not look very long at a face that does not contain eyes. (Mussen, Conger and Kagan, 1979, p. 135).

In addition, Kagan (1979) suggested that a further change in the functioning of schemata is observed at 8 months. When infants between 3.5 and 29 months were tested for their attention to a repeated event, a drop in attention occurred at about 7 to 8 months. Kagan argues that from 3 to 7 months, attention wanes because the infant is developing mental schemata, in order to allow more rapid assimilation of a repeated event. After 8 months, attention begins to increase as a result of the emergence of a new tendency to compare the actual inputs in an active fashion to a stored representation in order to understand the way in which the current input is transformation of the stored representation.

1.2.1 The role of interpretation in cognitive development

Kagan claimed that all perceptual input is assimilated to perceptual schemata from a very early age. Changes in the course of development are due to the increasing availability of schemata and more active processes of comparison.

While Piaget agrees with the empiricists (Locke, Berkeley and Hume) in emphasizing that the infant needs to reinterpret originally uninformative or misleading perceptual information in order to reach sound conclusions about the world, the Gibsons disagree that interpretation of perceptual input is required. Kagan however introduces the process of interpretation to explain the infant's distribution of attention, rather than the validity of the infant's knowledge. The infant appears simply to assimilate perceptual input to schemata of differing degrees of complexity and the objectivity of such schemata is not discussed.

Kagan compared his own ideas and those of Piaget. He insisted that his notion of a schema is less tied to active manipulation than is the case in Piaget's theory. For Kagan, the infant is capable of forming a schemata for an object on the basis of mere visual inspection. "Available evidence is consonant with the view that infants can acquire knowledge of an event by looking listening or smelling; it is not always necesary that they manipulate it". (Kagan, 1979, p. 165).

It should be pointed out that this comparison misses a more essential difference between the two theorists. Piaget is interested with the infant's understanding how particular states of the world can be transformed into other states. Kagan claims that the infant can store some kind of abstract copy of that transformation. Piaget argues that the ability to store a copy is not adequate to ensure understanding of a transformation. The fact that the infant for example can store a mental representation or schemata for the optical information that is available when a stimulus moves behind a screen, does not indicate that the infant can understand how that information has been brought about and how it can be undone by the infant's own intervention.

1.2.2. <u>The role of experience in cognitive development</u>

Contrary to other theorists, Kagan is fairly explicit about the existence of innate processes, which guide the process of development, but which are not necessarily detectable at birth. Kagan explains the changing role of the schema in the light of a maturationally governed growth process which controls the infant's memory capacity. Evidence from cross-cultural work supports the view that changes in memory processes seem to be universal.

The elaboration of particular schemata, however, is based on specific encounters with the environment. Encounters that are quite different from existing schemata will elicit the most attention and therefore have the most formative role in revision of those existing schemata. However Kagan was not sure how such revisions take place. Does the infant produce a new schema which equates across both the old schema and the current encountered stimulus, or does the latter strengthen those aspects of the schema with which it does overlie while undermining those aspects from which it deviates? Kagan did not answer these questions.

1.2.3 The role of representation in cognitive development

The central point of Kagan's theory is that the infant gradually becomes less and less responsive to the immediate physical input. Both Piaget and Kagan agree in this respect, but the end point of development during the period of infancy is different for them. For Piaget the infant develops representational capacities around 18 months of age, that is at the end of the sensorimotor period. Before that - around 8 or 9 months - the infant's search for a hidden object does not involve true representation of such an object. Kagan, however, attributes a representational capacity as early as 3 - 4 months. For Kagan, representational capacities are recruited to explain the infant's distribution of attention to a visible event, so that the validity of such processes is not at issue. The function of those processes change in the course of development but the capacity to represent previous objects and events is an early achievement.

<u>Summary</u>

To sum up, with regard to the role of interpretation, Piaget has minimized the capacity of the infant to extract valid information. Gibsons' theory emphasises that direct visual perception becomes more and more appropriate. Concerning the role of experience in detecting invariance, the infant's knowledge does not usually develop in a stage-like way. In some cases, experience appears to extend but not alter the infant's initial mode of perception. This evidence is consistent with the Gibsons' suggestion of the fine tuning of a rich capacity for information extraction. As for the capacity for representation, there is evidence indicating that it comes to guide attention and imitation from an early age, in line with Kagan's assumptions.

2. Substantive findings: Detection of invariance and changes of orientation

The following section considers first the extent to which an infant can overlook certain variations in a face's appearance as it is subjected to various types of displacement, such as rotation or being moved toward and away from the infant. Such movements alter certain aspects of a face's appearance, but leave other aspects unchanged. The question to be answered here is whether the young infant is capable of detecting such invariance despite the accompanying variation, and what is the earliest age at which detection of invariance is possible?

Studies reporting the infant's ability to detect invariance across orientation reviewed below examined also whether infants can identify faces that belong to the same category. The category of female faces have certain features in common, but also differ in some others. To perceive that a face belongs to a specific category, the infant needs to be capable of detecting the invariance despite the accompanying variation. Accordingly, the question of membership and the detection of shape constancy across several types of displacements or orientations are the same in that they require that the infant see invariance in the presence of variation.

In accord with the direct theory of perceptual learning, Gibson and Gibson argue that there are invariants of stimulation, which the infant becomes better able to detect, and that such an improvement does not necessitate the infant's enriching the information given by attaching similar or higher order responses to initially disparate stimuli. The present thesis argues that the infant's capacity to understand the transformations of a face is crucial for the realization that he is dealing with a single face. Accordingly the direct theory is inadequate in its explanation of the detection of invariance across examples of a category. An alternative view is to suppose that category members are coded in terms of their similarity to a mental prototype or schema as proposed by Kagan (1971). As mentioned earlier Kagan argues that infants from an early age can construct a mental schema which may not correspond to any object the infant has already seen, but constitutes an idealized version of a set of objects. Though Kagan did not provide an accurate explanation about how such schemata are formed, research by Cohen (1979), Strauss (1979) and others reviewed below support that such prototypical representations are present in infants. The question to be addressed: Can neonates build up a mental schema to include the various poses of the mother's face? If so, then infants understand from birth that they deal with a single mother, but in various poses, rather than with different mothers. Before describing research on the infant's ability to detect invariance across representations of faces, it should be noted that the neonates' capacity to perceive invariance across variation has not yet been examined, nor has the ability of infants to process invariant information across poses of the mother's face, a highly familiar stimulus.

Most of the studies which explored the extent to which an infant can detect similarities across different orientations of the same facial stimulus used the habituation and familiarization paradigms to study the response to novelty. First, the infant was familiarized with one or more faces and then tested for the extent to which familiarity was transferred to other faces that varied in their similarity to the stimuli presented during the familiarization period. Most of the studies, if not all, tested the hypothesis that infants will pay more attention in a recognition test to faces that appear novel rather than familiar. Since the results of these studies appear to be related to the technique used, a full description of the procedure is given.

Cornell (1974) used a familiarization technique to examine 19 and 23 week-old infants. The subjects were shown photographs of different adults' faces which shared sex-class features, differing poses of the same face, or repeated exposures of the face that served as a test stimulus. There were 3 sets of 8 faces: 1) Photographs showing male and female adults in full-face, 2) Photographs of different poses of one male and one female

(3/4 profile, looking up, looking down) and 3) Two pairs of photographs, two identical male faces and two identical female faces (see Cornell's stimuli) below).

Fig.5.1 Cornell's stimuli.

The subjects were divided into groups, so some of them saw photographs of differing faces sharing sex-class characteristics, the other group was presented with photographs of differing poses. Each subject was assigned to one of three familiarization conditions. A series of six familiarization pairings was presented, followed by two stimulus pairings which made up the immediate recognition. Each of these eight presentation trials were of 10-sec duration. After a 2 min paired presentations of black and white patterns, the stimulus faces were used in a delayed recognition test. These were also shown for 10-sec. Infants fixated more a novel face which shared the same features with a familiar face. Twenty three week-olds could discriminate between the test photographs following each familiarization condition, whereas 19-week-olds failed to show any discrimination. No information was provided about the infants' recognition of faces in different poses. For Cornell, experience with different faces in the same class or varying transformations of the same face leads to better visual differentiation than seeing the same face a number of times with no changes.

The finding that 23 week-olds were able to recognize the features common to a given class suggests, at least, that by 23 weeks infants can detect invariance but it does not indicate that they understand that the features belong to different faces.

Fagan (1976) who adopted a habituation technique demonstrated that 7 month-old infants are able to distinguish between two orientations of the same face.

In the two first experiments Fagan examined the infants' ability to discriminate among photos of adult male faces. Pairs of faces selected by adults as more or less similar were used to investigate whether features contained in some poses make it easier for an infant to discriminate among faces. The faces of 4 men were presented in full-face, three-quarter or profile views (see Fagan' stimuli below).

Fig.5.2 Fagan's stimuli

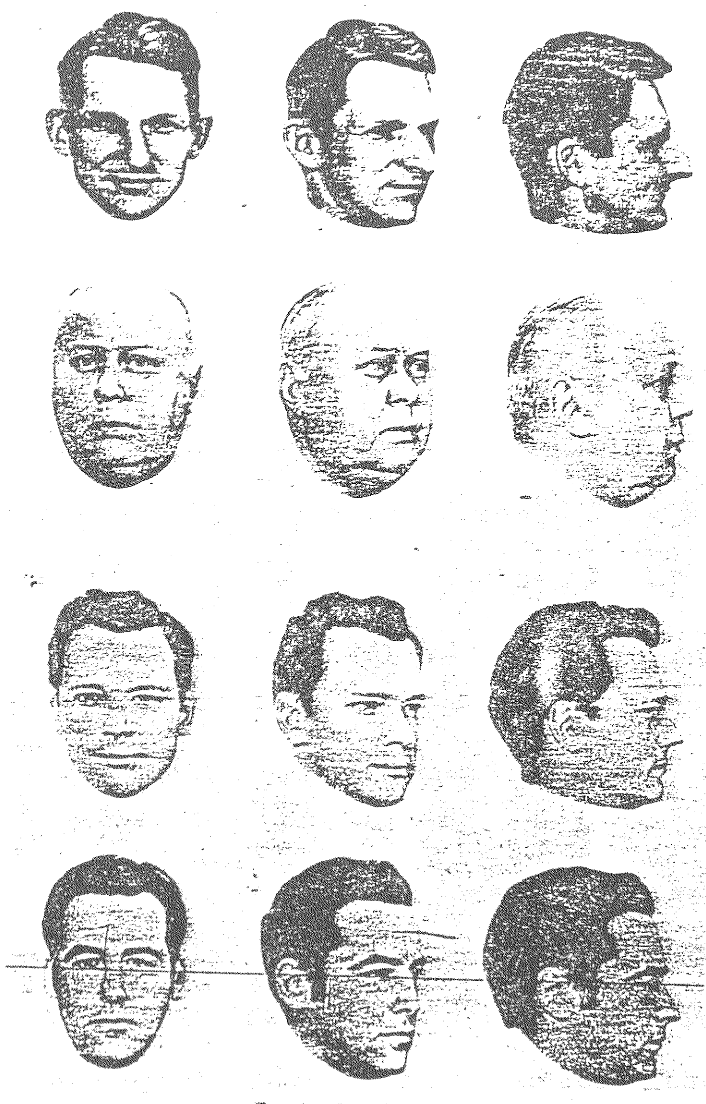


FIG. 1.—Stimulus targets

Each infant was exposed to a pair of identical faces for a 40-sec familiarization period. The recognition test consisted in showing one of the previously exposed faces with a novel one for two 10-sec trials. Faces that were judged highly discriminable by adults were easily distinguished by infants with preference for the novel face being shown regardless of the pose during the recognition test. The faces judged low discriminable by adults were also found difficult to distinguish by infants.

In experiment 2, Fagan studied 7 month-old infants' ability to discriminate between two poses of the same male face. Each infant was presented with a particular pose of a face paired with itself for 40-sec (e.g. full-full) followed by a recognition test of two 5-sec pairings of the previously exposed pose with a novel pose of the same face (full profile). Infants then were exposed to a second 40-second exposure of the previously seen pose (full-full) and a pairing of that pose with the remaining pose for recognition testing (full-three quarter). Finally, the pose just presented as novel (the three quarter) was shown for another 40-sec and then paired for testing with the novel pose exposed in the initial recognition test.

At 7 months of age, infants were able to discriminate one pose of a face from another. This finding suggests that infants of this age are quite capable of identifying the invariant of the previously seen face perhaps because features common to the two poses of the faces had been abstracted.

Fagan's experiment 3 examined the 7 month-olds' ability to detect invariant aspects of faces and the infants' attention to unique aspects of face patterning and to specific characteristics of poses.

A group of 32 seven-month-old infants was tested for identification of invariant features of a male's face, invariant over changes in pose. All the subjects were shown one pose (full) of a man for 40 sec followed by a 10-sec recognition test composed of either of profile poses of the two men paired for half the subjects or by pairing of three-quarter views of the two men for the other half. All the subjects were given a second 40-sec exposure to the full face of the male seen earlier, followed by a test of the three-quarter poses or the profile poses, a pose they did not see before. The other 20 subjects were tested for recognition of invariant pose over changes in face patterning.

The 32 infants were able to recognize the familiar face on testing even though it was shown in different poses during familiarization, and even such a change in pose could be easily discriminated, as indicated in experiment 2.1.

However, discrimination of one man from another under conditions of changes in pose from familiarization to testing was lower than differentiation between the same two men who were exposed in the same pose.

The other 20 subjects were also capable of detecting the invariance in pose over changes in face patterning, as indicated by preference for the novel pose. As Fagan suggested this could not have been due to a failure to dicriminate between the face patterns of the two men who held the same familiar pose from training to testing in this experiment. Thus, invariance in pose could be identified even when face pattern did not change from familiarization to testing.

In the fourth and fifth experiments, Fagan studied the 7 month-old infants' ability to detect general characteristics defining adult male or female faces. The possibility that infants are capable of such abstraction was first raised by Cornell's (1974) study cited earlier. Forty subjects were presented with full face poses. A 40-sec familiarization session was given for 16 subjects. The faces of two women were presented, followed by 5-sec pairings. Another 24 subjects were tested for detection of general facial characteristics of men or women.

The 16 subjects asked to discriminate between two women on the full face pose showed a novelty preference indicating that 29 week-old infants can identify features characterizing females. For the 24 subjects, preference for the novel face was found on the first 10-sec recognition, as well on the second recognition test. Nevertheless, this latter preference for the novel face does not provide evidence that infants had abstracted the invariant features defining male or female faces and that these features give the basis for recognition. Fagan explained that the familiar face on the second test might have been recognized as having appeared on the first recognition test. Second, the infants might have abstracted the features peculiar to one sex and had based their novelty preferences on those features. The repetition of the same face from one test to the next may have influenced the results.

These possibilities were tested in experiment 5 using 48 subjects. The stimuli used by Fagan were full-face poses of men and women. Infants were capable of abstracting the characteristics defining adult male or female faces and utilized this information as a basis for later recognition. Exposure to multiple instances of the same sex during familiarization seemed to help the abstraction process. Fagan suggested that such an effect was shown in experiment 4 and might have been found in Cornell's (1974) study. Thus 29 week-olds are able to perceive invariance in faces and even detect features that define sex.

Fagan's research showed that by at least 7 months infants are capable not only of discriminating between two faces, but also between two poses of the same face. Further, they were able to identify the variant of the previously seen face, perhaps because features common to two versions of the face had been abstrated during familiarization. Three instances of this capacity were demonstrated. First, infants responded to a man's face as familiar on a recognition test, though a different pose of that face had been shown previously. Thus, features common to different poses of the same face were recognized. Second, infants responded to invariance in pose, recognizing a particular pose as familiar though the man who was shown on that pose during the familiarization exposure was not the same one presented during recognition testing. Third, infants evidenced the capacity to discriminate facial characteristics indicative of men and women by identifying a face as familiar on recognition testing when another instance of that same-sex face was shown for initial recognition.

Cohen and Stauss (1979) compared three age groups (18, 24 and 30 weeks) in a similar study to that of Fagan (1976). In condition 1, infants were habituated to a chromatic photograph of a female face shown repeatedly in the same pose, the same face in the same orientation. In condition 2, the same face was shown in varying orientations (four 3/4-side orientations: looking to

upper left, lower left, upper right and lower right). Cohen and Strauss assumed that such variegated experience might instruct the infant to treat the various poses as instances of a single concept; that is if infants were acquiring the relevant concept, dishabituation must occur only to the novel face, and not the same face in a novel orientation. In condition 3, both faces and orientations were varying from trial to trial.
All subjects received a black-and-white checkerboard pattern on the first and last trials. Also, all of them saw faces (in habituation and posthabituation) in one of the four orientations and displaying one of three expressions (smile, frown or surprise). In the habituation phase, infants were shown one or more stimuli until their mean fixation times on three consecutive trials reached a criterion of less than 50% of the mean of their first three fixations.

Seven month-old infants were capable of recognizing a face previously viewed in one pose (full-face) as the same when presented in another pose (three-quarters profile facing upwards). Apparently infants of this age can learn a variety of categories ranging from a particular orientation of a face regardless of orientation, to faces (or at least female faces) in general.

In contrast, the younger infants (18-24 weeks) were sensitive to a change from 3/4 profile to full face orientation, but were not able to discriminate the invariant features of a particular face or of faces in general. Thus, at this age, infants do not seem to have constructed a concept to include the various possible orientations of the familiar face but had only coded those specific orientations of the face they had previously viewed. Cohen and Strauss argued that infants might have simply preferred to look at faces in a frontal orientation than at the same faces in a side orientation (combined orientation and expression).

In another study by Cohen and Strauss (1977) 18-22, and 26 week-old infants were habituated either to full face pose or 3/4 profile and then tested with the opposite view. At all ages infants dishabituated, indicating that they recognized the novel pose from the pose seen previously. Infants seemed able to encode the distinctive features of faces.

When the live face of the mother was used, infants as old as 20 weeks showed preference for the silent 90° presentations in Watson et al's (1979) study. The infants were exposed to eight facial presentations, each lasted 30 sec. The infant's mother and a distinctively unfamiliar bearded male wearing glasses were presented at 0° orientation aligned with the infant's face, and at 90° orientation at right angles to the infant, but facing the subject. Watson et al did not provide pictures of their stimuli.

Fourteen week-old infants smiled longer at silent 0° faces than at silent 90° presentations, 20 week-olds did not. Older infants showed a more complex discriminations, responding on the basis of several facial features; the mother's talking full face attracted the infant's attention more than did the faces of the mother and stranger which lacked these characteristics. These results are in accord with those reported by Watson (1966) that the strength of preference for a silent full-face declines after 14 weeks of age. The same decrement in preference for uprightness with strange faces either talking or silent was found at this age.

Summary

The infants' ability to extract invariant information in faces across different orientations has been reported in studies which used habituation and familiarization techniques from 7 months of age (Fagan, 1976); and from 6 months of age (Cornell, 1974; Cohen and Strauss, 1977; Cohen and Strauss, 1977) or perhaps from 4 months of age (Watson, Hayes, Vietze and Beckér, 1979) when the live face of the mother was accompanied by voice cues and movements of the mouth.

Thus, infants at ages ranging from 6 to 7 months are able to recognize a photographed face seen in one pose (e.g., full face) as being the same face when viewed in a different pose such as profile (Fagan, 1976) or 3/4 profile facing upwards (Cohen and Strauss, 1977) or facing downwards (Cornell, 1974).

The mother's face seen in one pose (full face) was also recognised as the same when viewed in another pose (90^{o} orientation) with infants devoting more smiling to the 0^{o} orientation. But while preference for the mother's face presented in the 0^{o} orientation declined after 14 weeks, it was greater for the mother's talking face in view at the same orientation after 20 weeks of age.

The ability to recognize a particular face despite the accompanying variation suggests the presence, at least, of certain processing of invariance across time and presentations. By 3 months of age this capacity is fully developed. The infant is not only able to discriminate the distinctive features of a given face but also becomes familiar with a set of class features such as faces sharing sex-class characteristics (Cornell, 1974, Fagan , 1976). For instance, infants responded to invariance in pose recognizing a particular pose as familiar even though the male who had assumed that pose during the familiarization exposure was not the same male shown during recognition testing (Fagan, 1976). Thus, infants are capable of discriminating different instances, not of the same face, but of the same class (sex or pose) of faces as being similar to one another. They seem to have established a concept of category membership. This ability suggests that infants of this age are relatively good at detecting invariance across a set of varied instances.

The question of whether infants can detect invariance has been answered though the evidence for it comes from only a few relevant studies. With respect to the second part of the question, that is the earliest age at which processing of invariant information is possible, this is not yet clear. Studies described in this section reported such ability around 6-7 months. Whether young infants are capable of recognizing the mother's face viewed in different poses has not yet been examined.

3. Sex differences in perception of invariance

In the studies by Cornell (1974) and Fagan (1976) there was no evidence that responsiveness to invariance in the presence of variance and the ability to process information about pose was influenced by the sex of the infant.

Watson, Hayes. Vietze and Becker (1979) who showed their 20 week-old subjects the mother and a bearded male's face at 0° and 90° orientations found that females smiled more at their mother's full face than at either their mother's 90° or a stranger's 0° face, but male subjects failed to distinguish between their mother and a stranger when both faces were aligned with their own; nor did they differentiate between 0° and 90° orientation of their mother's face, they smiled longer at their mother than at the stranger when both faces were presented at 90° orientation. They also discriminated between 0° and 90° orientation of the stranger's face.

Watson et al.'s finding of a difference between sexes in responding to different orientations of their mother's face was suggested by data on mothers' verbalization frequency as a function of the sex of their infant. Lewis (1972) reported that mothers of 3 month-old females vocalized significantly more to their infants than mothers of males. But Moss (1967) noted no differences in vocalization frequency to 3 month-olds. Lewis' data indicated that mothers of females may more often respond contingently to infant vocalizations than do mothers of males. During a 10-sec interval in which the infant vocalized, mothers of girls were more likely to vocalize, but mothers of males were equally likely to hold the infants without vocalizing or vocalize to them.

Since Watson's (1967b) result indicated that mothers establish facial alignment when attending to their infant's faces and Lewis' result suggested that, by 20 weeks of age, females have significantly more training that the 0°, talking face of their mother predicts contingent vocalization, it is perhaps not surprising that females appear to be more responsive than males to the mother's 0° full face.

Summary and Conclusion

The capacity to detect invariant information across different poses seems not to be influenced by the sex of the infant. However, while females demonstrated stronger preference for the mother's 0^{o} (full face) than for either their mother's 90^{o} face or a strange bearded male 0^{o} face in Watson et al., (1979) study, males were not able to discriminate between the 0^{o} and 90^{o} orientations of their mother's face, nor were they capable of differentiating between two poses of the same face. It should be however noted that Watson et al's study reporting sex effect used a different measure of attention (smiling) as well as different stimuli and procedures. The infants' performance might have been influenced by variables such as stimulus movement rather than demonstrated a substantial effect of sex.

4. Methodological issues

Age of the subjects

The few studies which looked at the infants' ability to recognize a face as the same when shown in another pose, only examined older infants, and none of them was replicated on neonates. It is possible that infants under 14 weeks of age are capable of processing the invariant information particularly because information can be defined at various levels of abstraction. The mother's live face contains, of course, several abstract information such as depth, brightness etc., but it can be recognised by a neonate only a few hours after birth. If the newly born infant is capable of such discrimination, then the processing of some level of invariance may be possible in the neonatal period.

It follows that it is fundamentally important in this type of research (a) to investigate the age at which processing of invariance is possible, and (b) the level of invariance the infant is capable of processing.

Techniques

Most of the findings suggesting the infants' capacity to recognize a face seen in one pose as being the same face when it is viewed in a different pose were based on the familiarization or habituation paradigm (Cornell, 1974; Fagan, 1976), others have come from research which adopted habituation-dishabituation (Cohen & Strauss, 1979), or a natural reaction technique such as smiling (Watson et al (1979).

These different techniques yielded different kinds of informtion about the infants' visual behaviour. For instance in Watson et al's study, sex differences were reported, with females showing preference for their mother's 0^{o} face and males smiling more at their mother's face presented at 90^{o} orientation. This finding seems interesting because it derived from natural reaction procedure which did not expose the infants to a long familiarization with the stimuli. This means that the 14-week-old infants are capable of detecting and processing the differences between two stimuli without particular familiarization or prompting.

In the familiarization procedure, differential responding suggests that the infant under certain circumstances detects a difference between two faces, but it does not say anything about the importance of this distinction in the everyday life of the infant, nor does it imply that the infant can necessarily discriminate between the two faces without the specific preparation of training with one. However, it does accord quite well with Gibson's (1969) view that after visual experience with a particular object, the infant is able to discover the invariant characteristics of that object. However, though familiarization is one form of visual experience considered important for perceptual learning, it may be in some cases (Cornell, 1974) too long, and may thus lead to fatigue in subjects which would affect their performance.

Difficulties emerging from the use of habituation technique have been noted by Cornell (1974). The presentation of the same sex-category features or a new pose of the same face seemed to have influenced the data obtained.

Stimulus type

In most of the studies described above there is a methodological difficulty which makes interpretation of the results equivocal. This is the issue of stimulus type used by researchers examining the infants' capacity to detect invariance across poses. Cornell (1974) and Fagan (1976) adopted achromatic photographs. Cohen and Strauss (1979) used chromatic photographs displaying expressions. Only Watson et al., (1979) employed the live faces of the mother and they used an unusual stimulus, a distinct bearded male stranger throughout the study.

Also in some studies the infants were presented with stimuli other than faces. They were shown, for instance, abstract black and white patterns following habituation period and prior to delayed recognition in Cornell's study, and black and white checker board pattern on the first and last trials in Cohen and Strauss' research. The number and varied type of stimuli used in this study might have accounted for the 18 and 24 week-old infants' inability to process the invariant information about features of a particular face or of faces in general.

Watson et al., (1979) combined familiarity, liveliness and voice cues and found that the mother's 0° face elicited more smiling in 14 week-old infants than faces which lacked these characteristics. Perhaps if research adopted live faces rather than photographs the perception of invariance in faces across time and presentations would have been demonstrated in younger infants.

Difficulties related to the stimulus figures have been noted by the researchers themselves. For instance in Cornell's (1974) study the information within the familiar stimulus appeared to have been made more attractive by showing a new pose of a face that served as the stimulus figure in the familiarization phase. This bias in the design may have led infants in condition 3 (see the study above) to attend to the completely new stimulus when paired with the familiar one.

The size of faces in photographs could also affect the infants' responses. Fantz and Fagan (1975) and Miranda and Fantz (1971) independently manipulated size and number of squares in black-and-white patterns. Both the number and size of internal elements influenced visual attention in newborn to 6 month-old infants. The infants looked longer at patterns with larger elements. Size had a strong effect on the fixation time of the youngest infants, but had a smaller effect with increasing age. Future research should use live faces so that one can be able to generalize the obtained result to the real world.

Method of stimulus presentation and length of trials

In the studies reviewed above, longer trials must have improved performance in younger infants, since they are slower information processors.

Summary and Conclusion

The first part of this chapter discussed briefly two important theories for studying the infants' capacity to process invariant information. While the first one stresses the role of experience in detecting the invariance (E. Gibson, 1969), the second claims the presence of innate processes which guide the course of development but which could not be detectable at birth, and that the infant builds up a mental schema for an objection the basis of visual inspection. (Kagan, 1979). For Gibson, the infant can pick up information from birth, but would fail to discriminate between the individual faces. Gradually, with experience, the infant would learn to attend to the distinctive features while ignoring those that stay constant across face. After 8 months attention begins to increase because of the emergence of a new tendency to compare current inputs to a stored representation so as to understand the way in which the present input is a transformation of the stored representation. Although Kagan's theory is stronger than the Gibsons' in that it suggests the infant's understanding of the process of comparison, it posits that the ability to detect invariant information is not functioning at birth.

Support for this view has come from the few relevant studies described in the second part of this chapter. Infants from the age of 6 and 7 months were able to recognize a face as being the same when viewed in another pose or orientation.

Differences between younger and older subjects in their responsiveness to invariance across presentations of the same face were found, with older infants demonstrating greater capacities than did younger. The capacity to process invariance was not apparently influenced by the sex of the infant.

The procedures and stimuli used in these studies could have accounted for the results that older infants appear more capable of processing invariance about poses. The adoption of photographs (achromatic and chromatic) of different sizes instead of real faces may restrict the findings to two-dimensional stimuli and not allow their generalization to real faces. Future studies are needed to find out whether neonates can detect invariant information.

Aims and hypotheses

If an optimal methodology is used and optimal stimuli are employed, it ~~is~~ MAY BE possible to demonstrate the detection of invariance across facial pose in infants younger than previously shown. Since neonates have been clearly demonstrated to recognize their mother's face, it seems likely that this ability must involve at least a limited capability to deal with the commonality amongst a variety of poses and expressions exhibited by that face.

CHAPTER 6

EXPERIMENTS INVESTIGATING THE YOUNG INFANTS' CAPACITY TO EXTRACT INVARIANT INFORMATION ACROSS FACIAL POSES

Introduction

The present chapter reports a series of experiments designed to explore the young infants' capacity to process invariant information across facial poses. Are there any difference in the infants' ability to detect invariance as a function of their age? Is this capacity sufficiently developed in the neonatal period to allow the establishment of the conceptual equivalence of a specific face across different poses.

As pointed out in the last chapter, the infants' capacity to abstract those unique aspects of the mother's face which remain invariant from one pose to another has not yet been studied. Neither has the ability of neonates to recognize the mother's face viewed from different angles, or to abstract the relevant categorical information from any set of changing stimuli. Only a few studies have investigated the processing of invariant information in older infants.

The existing evidence suggests that from 5 months on, infants become increasingly capable of abstracting invariant features and relations among features. Cornell (1979) reported data indicating that 6 month-old-infants recognized the features of a face they had not seen previously, but which shared the same features with a face they had been familiarized with. Fagan (1976) and Cohen and Strauss (1979) have shown that at 6 or 7 months infants are capable of recognizing a face viewed in one pose as being the same face seen in a different pose.

Discrimination between different orientations of the same face or several faces was found even when live faces and natural reaction procedures were used (Watson, Hayes, Vietze and Becker, 1979). The mother's upright talking face elicited a greater amount of smiling from 5 month-old-infants than did the mother's 90 ^{o} face or a stranger's 0 ^{o} face in Watson et al's study. Also the silent 0 ^{o} faces of both the mother and the male stranger were preferred to silent 90^{o} presentations by 3-4 month-olds.

Thus, infants from 5 months of age showed not only that they can extract invariant information and acquire a concept, but that they could acquire different levels of concepts depending on the procedure used and on which habituation condition they received.

However evidence demonstrating the ability of infants to respond to invariance has come from studies which adopted different procedures and type of stimuli. Perhaps if the animation and familiarity dimensions were combined, detection of invariant information would be found at an earlier age. In fact, the previously demonstrated neonates' recognition of their mother's face when displaying static expressions requires the capacity to process at least some level of invariance as well as the abstraction of at least one unique aspect of the mother's face. What is the extent of this ability? Can neonates acquire a variety of conceptual categories ranging from a particular orientation of a face, to a particular face regardless of orientation? What is the critical time for the development of a conceptual representation of the mother's face?

Experiment 6.1

The processing of invariance by newborn infants

Introduction

The purpose of this experiment was to examine the neonates' capacity to recognize their mother's face when viewed in another pose. Can newborn infants abstract unique features which remain invariant from one pose to another. Does recognisability decrease with the increase of angular deviation?

Since neonates have proved to be capable of recognising the en face pose of the mother even when the mother's and stranger's faces were matched in terms of hair colour, facial brightness, and olfactory cues were controlled, it is possible that they could also discriminate the mother's face despite a change of orientation.

As in the previous experiments of this thesis, the faces were matched as closely as possible for hair colour, hair length and facial complexion. The olfactory information was also controlled.

In addition, it was seen advisable to include sex as a factor, as differences between sexes in responding to different orientation of their mothers' face are suggested by data of 5 month-old-infants (Watson et al., 1979) with males spending more time smiling to the stranger's 90° face and females preferring more their mother's 0° face.

Further, a control over experimenter bias was implemented by running all the subjects in this study with the observer and baby-holder blind as to the identity of the neonate's mother and the female stranger.

Method

The subjects were shown the faces of their mother and the face of a particular lactating female stranger of comparable hair colour and complexion, both appearing in the 3/4 profile. In the 3/4 profile pose, the faces of the mother and the strangers were turned away from the en face pose by 45° towards the outer edge of the screen. (~~see Figure 6.1.1 photo below~~).

Since preference for the en face pose of the mother was obtained in experiments 2.1, 4.1 and 4.2 where visual information was present and that the 3/4 profile pose involves only a slight rotational deviation around the vertical axis from the en face pose, a preference for the mother's face was expected to be found. It was anticipated that such preference would be based on neonates' experience with their mother's face.

Figure 6.1.1 An example of stimuli in 3/4 profile (this pair was not actually included in this experiment).

Though infants differ in the amount of time exposure to the mother's face, they all spend some time in face-to-face interaction in which the newly born infant encounters the mother's face from different angles and is likely to associate pleasurable experiences with it.

Subjects

These were 14 Caucasian neonates (7 male and 7 female). They were all healthy and apparently normal infants, as indicated by their Apgar scores after birth (Mean Apgar score at 1 min was 6.93, sd = 1.83, (range 5-10); at 5 mins was 9.24, sd = 0.56, (range 8 - 10).Their mean age was 51.45 hours, sd = 36.23 (range 11.30 - 160hrs). The difference between males and females was not significant by t-test (t = -0.66, df = 12, ns). Their mean birth weight was 3.63, sd = 0.56 (range 2.65 - 4.61 kg). The difference between male and female subjects in birth weight was also not significant as indicated by t-test (t = 0.08, df = 12, ns). Table 6.1.1 shows the subjects' sex, age, birth weight and Apgar scores.

Table 6.1.1. Subjects' sex, age, birth weight and Apgar scores (N=14).

Ss	Sex	Age (hrs)	Birth weight (kg.)	Apgar at: 1mn	5mn
1	M	11.30	3.88	8	9
2	M	21.45	3.13	8	9
3	M	24.00	3.30	5	9
4	M	51.30	4.30	10	10
5	M	64.00	2.65	6	9
6	M	67.45	4.61	5	9
7	M	73.00	3.66	5	8
8	F	17.45	3.48	8	10
9	F	34.00	3.67	7	9
10	F	34.25	2.88	6	9
11	F	38.00	4.28	8	10
12	F	50.15	3.10	5	9
13	F	74.00	3.83	9	10
14	F	160.00	4.11	7	9
Mean		51.45	3.63	6.93	9.24
Sd		36.23	0.56	1.83	0.56

The birth method of 12 of the 14 subjects was normal (SVD), 1 was sectioned (LUSCS) and 1 was a forceps delivery (MCFD). Explanations of the terms are presented in Chapter 2.

A further 6 subjects were tested and excluded from the sample because of side bias in their looking behaviour. The final sample included equal numbers of breast- and bottle-fed infants.

Stimuli/Apparatus

The stimulus figures were the real faces of the infants' mother and an adult female stranger matched by an experimenter as closely as possible for hair colour, hair length and facial complexion. A different stranger's face was presented for each subject. The stimulus faces were not looking at the infant. They were turned away from the en face pose by 45° in the direction of the centre of the screen. Each face was presented both in left and right 3/4 profile. As there were two 20-sec trials, each face was seen once to each side of centre.

Procedure

In all respects, the same method and procedure were adopted as in experiment 4.2, including a control for olfactory cues. The subjects were tested in the same hospital, at the same time of day. The mother and stranger were instructed not to smile or make any facial expressions.

Results

Fixation times for the mother were expressed as percentages and are presented in Table A below. Table 6-1-2 shows the means. The percentage preference for the mother and stranger are set out in Figure 6-1.2.

Table A Percentage fixation times (in seconds) for the mother and the stranger

	Trial1		Trial2		Combined Trials	
	Mother	Stranger	Mother	Stranger	Mother	Stranger
Male						
	45.00	55.00	22.00	78.00	33.50	66.50
	23.50	76.50	60.10	39.90	41.75	58.25
	59.80	40.20	20.00	80.00	40.00	60.00
	89.00	11.00	45.00	55.00	67.00	33.00
	22.00	78.00	88.50	11.50	55.50	44.50
	6.75	93.25	17.50	82.50	12.00	88.00
	30.15	69.85	58.50	41.50	44.50	55.50
Female						
	74.50	25.50	18.50	81.50	46.50	53.50
	82.50	17.50	100.00	0.00	91.50	8.50
	27.00	73.00	33.00	67.00	30.00	70.00
	100.00	0.00	74.00	26.00	87.00	13.00
	72.00	27.00	93.00	7.00	82.75	17.25
	78.00	22.00	11.00	89.00	44.25	55.75
	7.50	92.5	36.00	64.00	21.50	78.50

Table 6.1.2. Mean percentage preference for the 3/4 profile pose of the mother across Sex and Trials

		Trial 1	Trial 2	Average
Sex	Male	39.5	44.5	42
	Female	63.1	52.2	57.7
		51.3	48.4	

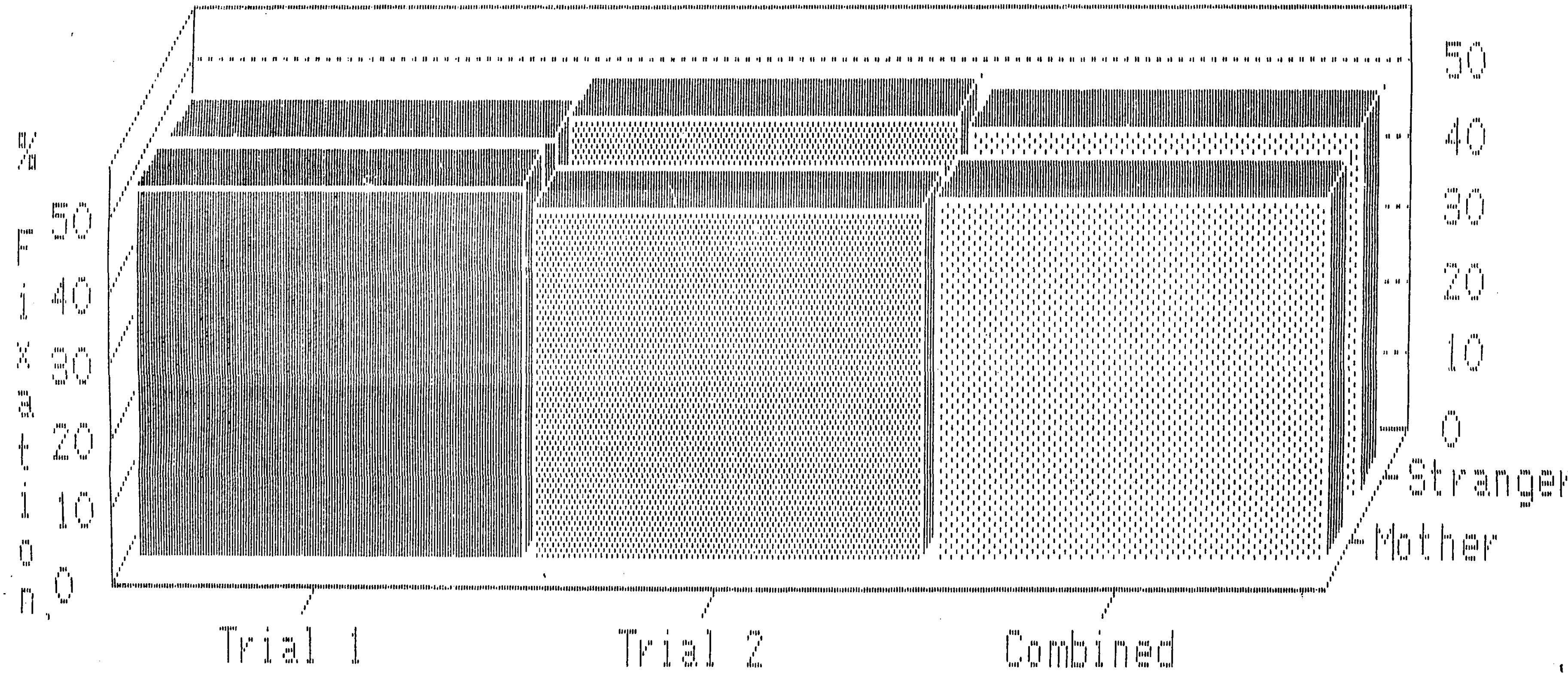


Figure 6.1.2 Percentage preference for the mother and the stranger across Trials in the 3/4 profile condition.

~~Recognition of the mother across sex and trials~~

Percentage preferences for the mother's face were analyzed using a two-way analysis of variance, with one between subjects variable, sex (male and female) and one within subjects variable, Trials (Trial 1 and Trial 2). Neither of the variables attained significance, indicating that there was no difference in response across Trials ($F(1,12) = 0.07$, NS), that is there was no preference for the mother or stranger, nor was there an obvious sex effect ($F(1,12) = 1.53$, NS), though female neonates demonstrated a slightly stronger preference for their mother's face ($M = 57.7\%$) than did males ($M = 42\%$), Table 6.1.2 shows these means). The interaction of Sex and Trials was also not significant ($F(1,12)$, $= 0.54$, NS) indicating that both males and females spent almost the same amount of time fixating their mother's face though male subjects looked more at their mother's face on Trial 1 ($M = 63.1\%$) than they did on Trial 2 ($M = 52.2\%$) or than females did on Trial 1 ($M = 39.5\%$). The Anova summary table is presented in Table 6.1.3.

Table 6.1.3. Preference for the 3/4 profile pose of the mother across Sex and trials by neonates

	Sum of Squares	DF	Mean Squares	F. Ratio	P. Values
Sex	1723.8604	1	1723.8604	1.5332	0.237157
Sex x Subj. Error	13492.2932	12	1124.3578		
Trials	60.3289	1	60.3289	0.0739	NS
Sex x Trials	447.2004	1	447.2004	0.5478	NS
Sex x Trials x Subj Error	9795.4132	12	816.2844		

Preference for the mother's face was further assessed by correlated t-tests, comparing visual fixations to the mother and stranger on Trial 1, Trial 2 and on both Trials combined. There was no preference for the mother's face on Trial 1 ($t = 0.15$, $df = 13$, NS), on Trial 2 ($t = 0.19$, $df = 13$. NS) or on the combined Trials ($t = 0.02$, $df = 13$, NS). The mean percentages preferences for the mother are listed in Table 6.1.4, where it can be seen that infants fixated the two faces almost equally. Table 6.1.5 shows the t-values.

Table 6.1.4. Mean percentage preference for the 3/4 profile pose of the mother on Trial 1, Trial2, and on the combined Trials

	Trial 1	Trial 2	Combined Trials
Mean	51.3	48.4	49.8
Standard deviation	31.80616	30.76906	24.26588
Variation	1011.632	946.7347	588.8328
Average deviation	28.17143	26.27347	19.22194
Coefficient of variance	62.00032	63.61938	48.68825

Table 6.1.5. One tailed t-test for preference for the mother's 3/4 profile face on Trial 1, Trial 2 and the combined Trials

	Df	t	p. values
Trial 1	13	0.15	NS
Trial 2	13	-0.19	NS
The Combined Trials	13	-0.024	NS

The relationship between the infant's birth weight and the extent of preference for the mother

The relationship between birth weight and extent of preference for the mother over the combined Trials was assessed by Pearson's Product-Moment Correlations and a negative, non-significant correlation ($r = -0.18$, NS) was found, suggesting that preference for the mother's face was not related to increased birth weight.

The relationship between the infant's age at testing and the extent of preference for the mother's 3/4 profile pose

Similarly, the relationship between age at testing and extent of preference for the mother's face was investigated using Pearson's Product-Moment Correlations and a negative, non significant correlation ($r = 0.19$, NS) was obtained, indicating that preference for the mother's face did not increase with age.

Number of fixations across faces

To determine whether neonates fixated the mother's and stranger's faces for the same number of time across the two trials, the three-way Anova was computed using one between subjects variable Sex (Male and Female) and two within subjects variables - Trials (Trial 1 and Trial 2) and Category of Faces (Mother and Stranger). Results of the analysis of variance showed no significant effects for sex ($F(1, 12) = 1.72$, NS), for Trials ($F(1,12) = 0.13$, NS), and for Category of Faces ($F(1,12) = 0.002$, NS). The Sex x Trials x Category of Faces ($(F)1,12) = 3.43$, NS) interaction was also not significant. Inspection of the means (Table 6.1.6) indicates that the neonates fixated both the mother and stranger with equal frequency across the two Trials. Also there was no difference between males and females in total number of fixations across faces. Table 6.1.7 presents the Anova summary table.

Table 6.1.6. Mean number of fixations across Category of Faces (Mother and Stranger), Sex and Trials

		Trial 1		Trial 2		
		Mother	Stranger	Mother	Stranger	Average
Sex	Male	4.0	5.6	5.8	4.0	4.8
	Female	5.0	4.0	3.0	4.4	4.1
	Average	4.6		4.3		

Table 6.1.7 Number of fixations across Category of Faces (Mother and Stranger), Sex (Male and Female) and (Trials (T1 and T2)

	Sum of Squares	Df	Mean Squares	F. Ratio	P.Values
Sex	7.8750	1	7.8750	1.7227	0.210992
Sex x Subj. Error	54.8571	12	4.5714		
Trials	1.4464	1	1.4464	0.1353	NS
Sex x Trials	3.0179	1	3.0179	0.2823	NS
Sex x Trials x Subj. Error	128.2857	12	10.6905		
Category of Faces (Mother and Stranger)	0.0179	1	0.0179	0.0028	NS
Sex x Category of Faces	0.4464	1	0.4464	0.0702	NS
Sex x Category of Faces x Subj. Error	76.2857	12	6.3571		
Trials x Category of Faces	0.8750	1	0.8750	0.1001	NS
Sex x Trials x Category of Faces	30.0179	1	30.0179	3.4353	0.084053
Sex x Trials x Category of Faces x Subj. Error	104.8571	12	8.7381		

Number of changes in fixation between the two faces

To find out whether neonates sampled the two faces equally across trials, an analysis of variance was computed with one between subjects variable - sex (Male and Female) and one within subjects variable - Trials (Trial 1 and Trial 2). Although the previous analyses revealed no differences between male and female babies in their number of fixation and in their looking behaviour, it was considered advisable to include sex as a factor since the sex effect was found to be significant in some of the previously reported experiments. The Anova resulted in non significant Trials (F(F1,12) = 0.26, NS) and Sex effects (F(1,12) = 1.61, NS). The Sex x Trials interaction effect (F(1,12) = 0.06, NS) was also not significant, though male subjects tended to sample the two faces on Trial 1 more (M = 4.14) than did females on the same Trial (M = 3.43) or on Trial 2 (M = 2.57). (See Table 6.1.8). However, the differences were not sufficiently large to reach significance. The Anova summary table is presented in Table 6.1.9.

Table 6.1.8. Mean number of changes in fixations between the two faces across Sex and Trials

		Trials		
		Trial 1	Trial 2	Average
Sex	Male	4.1	3.9	4.0
	Female	3.4	2.6	3.0
		3.8	3.2	

Table 6.1.9. Number of changes in fixations between the two faces across sex and Trials

	Sum of Squares	Df	Mean Square	F. Ratio	P.Value
Sex	7.00	1	7.00	1.6154	0.225314
Sex x Subj.					
Error	52.00	12	4.3333		
Trials	2.2857	1	2.2857	0.2609	NS
Sex x Trials	0.5714	1	0.5714	0.0652	NS
Error x Sex					
x Trials	105.1429	12	8.7619		

Discussion

The present study fails to demonstrate that neonates are capable of recognizing their mother's face seen in three quarters profile, when the mother and stranger's faces are matched for facial brightness, hair colour and length, and olfactory cues are controlled. Familiarity preference reported for the en face pose by Field et al. (1984) and experiments 2.1, 4.1 and 4.2 of this thesis seems to be confined to the en face pose. Such a preference was not apparent with a small angular deviation.

It is likely that the amount of experience with a face is vital for the infant to develop visual recognition. In face-to-face interactions mothers establish facial alignment (Watson, 1967b), looking directly at the infant. Thus, the neonate primarily encounters the en face pose and associates it with pleasurable experience, and seems to develop a conceptual representation for the en face pose. The 3/4 profile pose is infrequently experienced. The infant sees it only occasionally as the mother does not keep the face oriented by 45° for much time. If, when attending to the neonate's face, the mother shows the 3/4 profile pose, the same pose is perhaps rarely encountered twice.

Hence insufficient experience with the 3/4 pose might have accounted for the neonates' failure to recognize the mother's face viewed in 3/4 profile pose. Perhaps if the neonates were with their mothers immediately prior to testing, they would have shown a short term memory effect. In the present study the neonate did not see the mother for at least 10 minutes, or much longer in some cases.

The interpretation of such null results is problematic because it is not clear whether they represent a transitional phase in preference shifts, a phase in memory development, or a disruption in memory. The shift may indicate a transition in which some neonates are still responding by showing a preference for the familiar, whereas others have already started responding with a preference for the novel face. If some babies shift their interest from familiar to novel faces before others, the effect on the group value would be to shift it to chance levels.

It should be pointed out that the present study used a few subjects to confidently rely on the finding that neonates are not able to recognize their mother's face. A further study using a larger homogeneous (with respect to age) sample is needed to clarify this matter.

In as much as the visual preference procedure has been shown to be a viable technique for studying early face recognition as demonstrated by the present research, it should prove to be a sensitive method for examining the young infants' capacity to detect invariance across pose and for tracing early development of conceptual equivalence of the mother's face. Nevertheless the experimental procedure remains one of the issues which future research should take into consideration when studying the abstraction of visual information in the neonatal period.

The difference between male and female babies was not significant, nor was the interaction of Sex and Trials. No Sex effect was expected, but Sex was included as a possible variable. Once again the results confirm the view that sex effect vacillates from one study to another.

The non-significant relationship between content of preference for the mother and age of the infant at testing indicates that age is not a potential variable. Similarly, birth weight does not seem to be an important factor in determining preference for the mother as demonstrated in all the previous experiments of this thesis. Though infants did not recognize the 3/4 profile pose of the mother's face, it was seen advisable to investigate these relationships, as the overall preference for the mother might have been influenced by some higher and lower scores.

The finding that neonates' number of fixations to the faces of the mother and stranger did not differ significantly accords quite well with the result of a non-significant difference in the length of fixations paid to the two faces. As with the duration of fixation, the number of fixations for the two faces was not influenced by the Sex of the subject. Further, the infants' number of fixations did not differ across Trials, suggesting that the neonates attended to both faces during the two trials.

There was also neither difference between males and females in number of changes in fixations made between the two faces. Nor was there a Trial effect indicating that the neonates' visual behaviour did not vary from one trial to another.

Conclusion

This study has demonstrated that under the present experimental conditions, neonates failed to indicate recognition of the 3/4 profile pose of the mother's face. Accordingly, newborn infants are unable to abstract features which remain invariant from one pose to another. Recognisability of the mother's face decreased with the increase of angular deviation. At this age, infants have stored one representation of the mother's face, the en face pose.

Recognition of the mother's face displaying static expressions surely requires the capacity to process invariance. The identification of the mother's face viewed in 3/4 and profile needs the ability to detect invariance. The results of this experiment suggest that perhaps the two capacities involve different levels of abstraction and that the second ability necessitates a higher level. With experience, the infant comes to establish one concept for the mother's face.

Experiment 6.2.

Recognition of the invariant features of the mother's face by 1-month-old-infants

Introduction

In the last experiment, newborn infants failed to recognize their mother's face viewed in 3/4 profile. It was suggested that neonates would have had less experience with the 3/4 profile pose than the en face, or perhaps the representation of this pose requires a certain level of abstraction which has not yet been developed in the neonatal period.

Aim

Experiment 6.2 explores the 1 month-old-infants' capacity to recognize their mother's face viewed in different poses. More specifically, the aims were to see if 1 month-olds can extract invariant information across poses by showing recognition of the mother 3/4 profile face. Though neonates showed successful discrimination of the full face of the mother, it was decided to include the en face pose to compare the performance of this age group to that of newborn infants. The full profile pose of the mother's face was also included. Developmental differences in the types of concept infants are capable of acquiring are expected. First, it was anticipated that

1 month-old infants would have been sufficiently familiarized with the en face pose of their mother's face and would show a preference for it, and they would recognize the 3/4 profile and perhaps the profile poses of their mother's face, so that preferences for the familiar face would be shown in these cases.

Since evidence suggests that mothers of 3-month-old females vocalized more to their infants than mothers of males (Lewis, 1972), that is females have greater experience with the mother's voice and face, than males, the sex of the infant was included as a factor in this study.

As in the previous experiments, the faces of the mother and the adult female stranger were matched in terms of hair colour and length, and facial brightness. The olfactory information was also controlled.

Finally, it was decided to use cross-sectional design, that is test another group of infants other than the one tested in the previous experiment to discard the possible effects of repeated testing that have been noted in longitudinal studies.

Method

Subjects

The subjects were 12 infants (6 male and 6 female) obtained from Rottenrow (The Royal Maternity Hospital, Glasgow) and were volunteered by their parents after an initial contact (see letters in Appendix 6.2.1) to come into the Developmental Laboratory at Glasgow University. All the subjects and their mothers were Caucasian.
The mean age of the infants was 36.6 days, sd = 3.83 (range 30 - 45 days). The difference in age between male and female subjects was not significant by t-test (t = 1.08, df = 10, NS). They weighed between 2.86 and 3.58 kg at birth (Mean birth weight was 3.33 kg, sd = 0.21). The difference between males and females in birth weight was not significant (t = 0.53, df = 10, NS).

The subjects were ~~randomly~~ selected from a popualtion of apparently normal infants. They were all full terms, healthy, with no evidence of postnatal difficulties as judged by their Apgar scores at birth (see Appendix 2.1.1 for further details about the Apgar scores). Their mean Apgar at 1 minute after birth was 7.75; sd = 1.23 (range 5 - 9); Mean Apgar at 5 minutes after birth was 9.58; sd = 0.49 (range 9 - 10). Table 6.2.1 shows the subjects' sex, age, birth weight and Apgar scores.

Table 6.2.1 <u>Subjects' sex, age and Apgar scores (N=12)</u>

Ss	Sex	Age (days)	Birth weigth (kg.)	Apgar at 1min	Apgar at 5mins
1	M	34	3.24	9	10
2	M	35	3.44	7	10
3	M	36	3.19	5	9
4	M	38	3.52	7	9
5	M	39	3.42	7	9
6	M	45	3.41	7	9
7	F	30	2.86	7	9
8	F	34	3.56	9	10
9	F	34	3.58	9	10
10	F	35	3.43	9	10
11	F	37	3.36	8	10
12	F	42	3.00	9	9
Mean		36.6	3.33	7.75	9.58
Sd		3.83	0.21	1.23	0.49

The birth method of most subjects (n = 8) was normal (SVD), 3 were forceps delivery (MCFD) and only one was sectioned (LUSCS). The explanations of these terms are presented in the method section in Experiment 2.1.

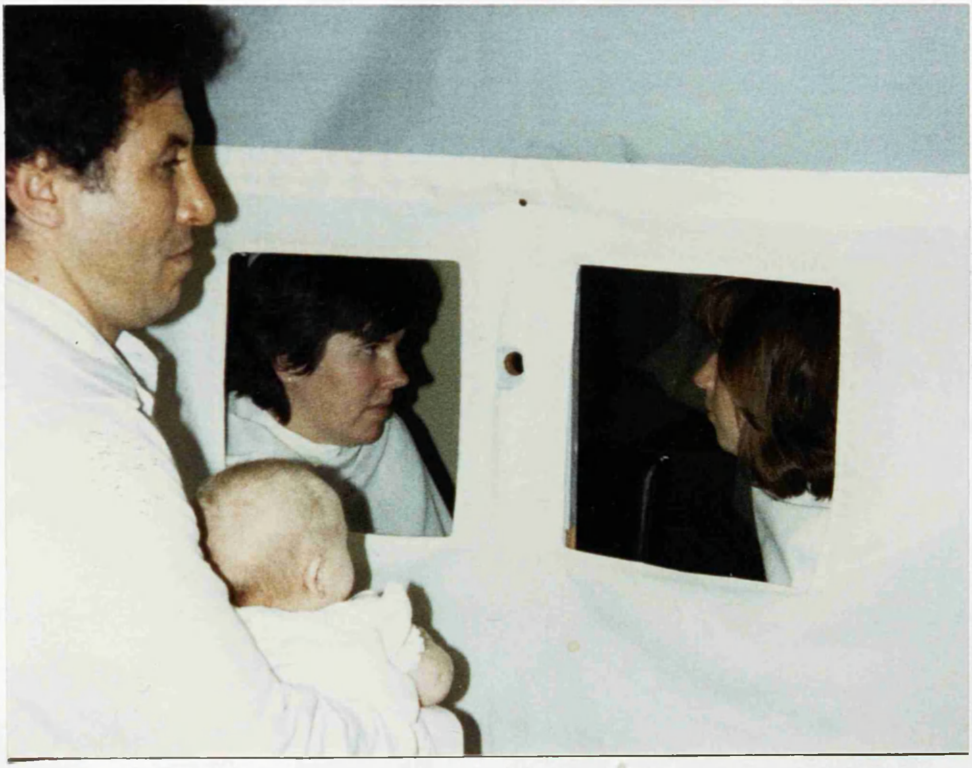
Nine additional subjects were discarded from this study. Of this group, 5 subjects were excluded because of side bias, 3 failed to complete the viewing task due to fussiness, and one was removed due to equipment failure to store the data of one of the conditions, and were not included in the analysis.

Stimuli/Apparatus

The stimuli were the real faces of the subject's mother and that of an adult female matched as closely as possible for hair colour, hair length and facial complexion. A different stranger's face was employed for each subject, but the same face was used for each subject across conditions.

There were three conditions: the en face, the 3/4 profile and the profile (see Figure 6.2.1 photo of the stimulus figures). In the en face pose condition, the faces were looking in the direction of the subject but not fixating the infant. In the second condition, the 3/4 profile pose, the mother and stranger were asked to turn their faces from the en face pose by 45° towards the centre of the screen. As there were two trials each face was seen once to each side of centre, both in left and right 3/4 profile. In the third condition, the profile pose, the faces were turned away from the full face pose by 90° towards the centre of the screen. As in the 3/4 profile condition, each face was shown both in left and right profiles across the two trials.

Fig. 6.2.1 Photo showing the profile pose condition. (This pair was not actually included in this experiment).



Procedure

Each subject and his/her mother was brought by taxi to the Developmental Laboratory in Glasgow University at a time of day which the mother held to be a good time for spontaneous alert activity on the part of her infant. Almost all the subjects were tested in the morning between 9.00 a.m. and 1.00 p.m. Only one subject was tested in the afternoon.

The mother and her baby were sat in a waiting room to rest from their trip and to allow the experimenter to obtain a volunteer female stranger from the University library. This was done after the arrival of the mother in order to match the mother and stranger as closely as possible for hair colour, hair length and facial complexion. The olfactory cues were controlled as in the previous experiments.

The same procedure was used as in the previous experiments, with the exception that each subject was tested under three conditions. Each infant, therefore, was involved in the following three discriminations between the faces of the mother and female stranger: (1) full face, (2) 3/4 profile and (3) profile. The order in which conditions were given was randomized across subjects. The direction of the orientation of the faces was also randomized. The order of presentation of the conditions should perhaps have been counterbalanced, but the problem of order-effects would in any event have been reduced by the lengthy intervals between testing sessions.

~~Results~~

Fixation times for both the mother and stranger were expressed in terms of percentages and are set out in ~~Figure 6.2.2.~~ Percentage preferences for the mother's face across the three conditions are presented in Table A below. ~~Table 6.2.2 displays the means.~~

Table A ~~Percentage fixation times (in seconds) for the mother and the stranger (Full face Pose)~~

~~Trial 1~~		~~Trial 2~~		~~Combined trials~~	
Stranger	Mother	Stranger	Mother	Stranger	mother
~~Male~~					
2.95	97.05	28.50	71.50	31.50	84.25
24.95	75.05	18.00	82.00	21.50	78.50
0.00	100.00	26.50	73.50	13.25	86.75
32.50	67.50	67.50	32.50	50.00	50.00
48.50	51.50	27.50	72.50	38.00	62.00
48.90	51.10	46.20	53.80	50.00	50.00
~~Female~~					
51.00	49.00	47.20	52.80	50.00	50.00
22.50	77.50	54.50	45.50	38.00	62.00
5.20	94.80	28.50	71.50	16.75	83.25
16.50	83.50	0.00	100.00	8.25	91.75
18.00	82.00	46.50	53.50	32.25	67.75
30.20	69.80	76.50	23.50	53.25	46.75

Only the en face data are given

Table 6.2.2 Mean percentage preference for the Mother across Sex (Male, Female), Poses (en face, 3/4 Profile and Profile and Trials (Trial 1, Trial 2)

		En face		3/4 Profile		Profile		
		Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2	Ave.
Sex	Male	73.7	64.3	75.3	51.4	58.2	53.8	62.8
	Female	76.1	57.8	60.7	72.4	25.0	63.9	59.3
	Ave.	67.9		64.9		50.2		
Means of Trials		74.90	61.05	68.00	61.90	41.60	58.85	

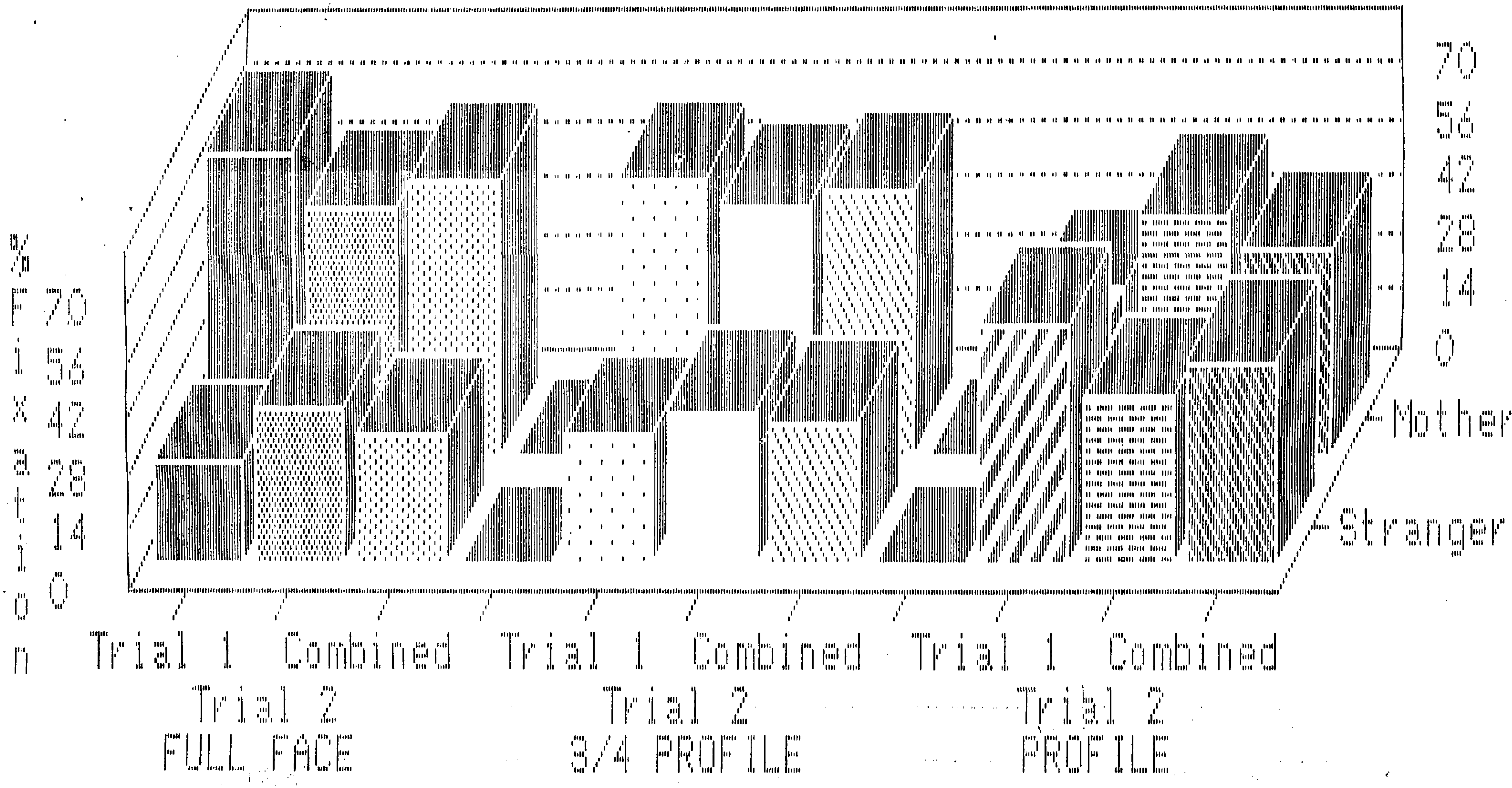


Figure 6.2.2. Percentage preference for the mother and the stranger across conditions.

Recognition of the mother's face across the en face, 3/4 profile and profile poses

Preference for the mother's face was examined in a three-way Anova with one between subjects variable Sex (Male and Female) and two within subjects variables, Pose (En face, 3/4 Profile and Profile) and Trials (Trial 1 and Trial 2). The only main effect to reach a level of significance was that of Pose ($F(2, 20) = 4.15$, $p < 0.05$).

A multiple t-ratio was computed to investigate the effect of pose and this resulted in significant preferences for the en face pose of the mother ($t = 2.69$, $df = 20$, $p < 0.01$, one-tailed) and for the 3./4 profile pose ($t = 2.23$, $df = 20$, $p < 0.025$, one-tailed) over the profile pose, but no significant difference was found between the en face and the 3/4 profile poses ($t = 0.46$, $df = 20$, NS).

No other main effect of Sex ($F(1,10) = 0.17$, NS) or Trials ($F(1,10) = 0.03$, NS) approached significance. The Sex x Trials ($F(1,10) = 5.21$, $p < 0.05$) and the Pose x Trials ($F(2,20) = 3.54$, $p < 0.05$) interactions were found to be significant, with male subjects demonstrating stronger preference for their mother's face on Trial 1 ($t = 2.09$, $df = 10$, $p < 0.05$, one-tailed) than did females on the same Trial (see these means in Table 6.2.2). The difference between male and female subjects on Trial 2 was not significant ($t = 1.13$, $df = 10$, NS).

One-month-old-infants looked more at the en face pose of their mother (m=74.9%) on Trial 1 ($t = 1.61$, df = 20, NS) than they did on trial 2 (m=61.05%), though the difference failed to reach significance. However, they showed stronger preference for the mother's profile pose (m=58.85%) on Trial 2 ($t = -2.0$, df = 20, $p < 0.05$, two-tailed) than they did on Trial 1 (m=41.6%). Though infants demonstrated more preference for the 3/4 profile pose on Trial 1 (m=68%) than they did on Trial 2 (m=61.9%) ($t = 0.71$, df = 20, NS), the difference was not large enough to reach significance.

Finally, both Sex x Pose ($F(2,20) = 0.64$, NS) and Sex x Pose x Trials ($F(2,20) = 2.68$, NS) interactions were not significant. The summary Anova table is presented in Table 6.2.3.

Table 6.2.3. Preference for the mother's face across Sex, Pose and Trials

	Sum of Squares	Df	Mean Square	F. Ratio	P.Value
Sex	218.7525	1	218.7535	0.1753	NS
Sex x Subj. Error	12605.4982	10	1260.5498		
Pose	4323.8944	2	2161.9472	4.1597	0.028922
Sex x Pose	672.7249	2	336.3624	0.6472	NS
Sex x Pose x Subj. Error	10394.6864	20	519.7343		
Trials	14.7604	1	14.7604	0.0314	NS
Sex x Trials	2448.8336	1	2448.8336	5.2130	0.042282
Sex x Trials x Subj. Error	4697.5658	10	469.7566		
Pose x Trials	3147.1997	2	1573.5999	3.5451	0.045525
Sex x Pose x Trials	2380.2369	2	1190.1185	2.6812	0.089802
Sex x Pose x x Trials x Subj. Error	8877.4910	20	443.8745		

Preference for the mother's face was further examined using correlated t-tests which indicated that infants looked at their mother's face more in the en face pose ($t - 3.70$, $df = 11$, $p < 0.005$, one-tailed) and in the 3/4 profile pose ($t = -3.86$, $df = 11$, $p < 0.005$, one-tailed), but infants demonstrated no preference for the profile pose of their mother's face ($t = -0.03$, $df = 11$, NS, one-tailed).

Preference for the en face pose of the mother was found to be significant on Trial 1 ($t = -4.83$, $df = 11$, $p < 0.0005$, one-tailed), but not on Trial 2 ($t = -1.77$, $df = 11$, NS, one-tailed), also the 3/4 profile pose of the mother received more fixations on Trial 1 ($t = -3.20$, $df = 11$, p

< 0.005, one-tailed) but failed to reach significance on Trial 2 ($t = -1.62$, $df = 11$, NS, one-tailed).

Infants failed, however, to make successful discriminations between the profile pose of their own mother and the profile pose of the female stranger's face both on Trial 1 ($t = 0.91$, $df = 11$, NS) and on Trial 2 ($t = -0.94$, $df = 11$, NS). Tables 6.2.4, 6.2.5 and 6.2.6 show the mean percentages preference for the mother's face across poses. Table 6.2.7 presents the t-values.

Table 6.2.4 Mean percentage preference for the en face pose of the mother's face on Trial 1, Trial 2 and on the Combined Trials

	En face pose		
	Trial 1	Trial 2	Combined Trials
Mean	74.9	61.1	67.8
Standard Deviation	17.8717	21.54287	16.56221
Variance	319.3977	464.0954	274.3068
Average Deviation	14.26667	17.45	14.29167
Coefficient of Variance %	23.86075	35.28726	24.44607

Table 6.2.5. Mean percentage preference for the 3/4 pose of the mother's face on Trial 1, Trial 2 and on the Combined Trials

	Trial 1	Trial 2	Combined Trials
Mean	68.0	61.9	64.9
Standard Deviation	19.46673	25.27862	23.41579
Variance	378.9534	639.0085	179.9834
Average Deviation	15.62917	19.98889	11.3275
Coefficient of Variance	28.62578	40.84883	20.65477

Table 6.2.6. Mean Percentage preference for the Profile pose of the mother's face on Trial 1, Trial 2 and on the Combined Trials

	Trial 1	Trial 2	Combined Trials
Mean	41.6	58.9	50.2
Standard Deviation	32.6146	32.3130	25.34191
Variance	999.4829	1044.134	642.2125
Average Deviation	26.47083	27.28472	17.71598
Coefficient of Variance	75.98902	54.89973	50.46095

Table 6.2.7. One-tailed tests for preference for the mother across Poses and Trials

		Df	t	P value
En face	Trial 1	11	-4.83	$p < 0.0005$
	Trial 2	11	-1.77	NS
	Combined Trials	11	-3.70	$p < 0.005$
3/4 Profile	Trial 1	11	-3.20	0.005
	Trial 2	11	-1.68	NS
	Combined Trials	11	-3.86	$p < 0.065$
Profile	Trial 1	11	0.91	NS
	Trial 2	11	-0.94	NS
	Combined Trials	11	-0.03	NS

The relationship between the infant's birth weight and the extent of preference for the mother's face

The relationship between the birth weight of the subjects and the extent of preference for the mother's face was assessed by Pearson-Product-Moment Correlation and positive non significant correlations were obtained for the en face pose ($r = 0.13$, $df = 10$, NS) and the profile pose ($r = 0.23$, $df = 10$, NS), but a negative non-significant correlation was found in the 3/4 profile pose ($r = -0.23$, $df = 10$, NS), suggesting that while recognition of the 3/4 profile pose tends to decrease with increasing birth weight, discrimination of both the en face and profile poses increase with birth weight increases though this tendency was not significant.

The relationship between the infant's age at testing and the extent of preference for the mother's face across poses

Further Pearson-Product-Moment Correlations were computed to examine the relationship between age at testing and the extent of preference for the different poses of the mother's face. Positive significant correlations were obtained both in the en face ($r = 0.63$, $df = 10$, $p < 0.025$, one-tailed) and in the 3/4 profile poses ($r = 0.57$, $df = 10$, $p < 0.05$, one-tailed). The relationship between age and amount of fixation to the mother was not significant in the profile pose condition ($r = 0.17$, $df = 10$, NS).

As previous analyses have shown no clear results from analyses of number of fixations for the mother and the stranger and number of changes in fixation between the stimulus faces and as they are of minor importance, no further analysis of these data will be undertaken.

Discussion

The present study demonstrates the ability of 1 month-old infants to recognize the face of their mother viewed in en face and in 3/4 profile poses when the mother and stranger's faces are matched as closely as possible for hair colour, hair length and face brightness, and when olfactory cues of the stimulus faces are masked.

The present results accord quite well with the previous findings of Maurer and Salapatek (1976) and Bushnell (1982) that 1 month-old infants are able to discriminate between the en face pose of their mother and that of an adult female stranger in the same pose. However they do not support Melhuish's (1982) data indicating the 1 month-olds' failure to recognize their mother's face, and their tendency to fixate faces with higher contrast. Also Bushnell (1980) showed that 5-7 week-olds required differences in the external outline of the face area (i.e. hairline) to discriminate, though older infants performed this discrimination on the basis of internal features alone. Similarly Salapatek (1975) Maurer and Salapatek (1976) and Hainline (1978) have reported that in the first month, infants concentrate their fixations on the outer boundaries of faces and geometric figures.

Since the present study used only Caucasian mothers with a white complexion and matched the stimulus faces for facial brightness, hair colour and hair length which should have confused the infants if they were basing their dicriminations on the hairline feature alone, the present results suggested that recognition of the mother's face is unlikely to be dependent on a simple featural aspect such as the hairline. By 1 month, infants might have abstracted some internal aspects characterizing a particular face. These suggestions are supported in part by the present results that 1 month-old infants are incapable of recognizing the mother's face when viewed in profile. It could be argued that if the infants were basing their discriminations on the external feature information such as the hairline, they would still be able to recognize a particular face, as the hairline is also obvious in the profile pose, providing that the infants had been exposed previously to this face.

It should however be pointed out that the above studies suggesting an outer boundaries effect present several methodological flaws. Melhuish (1982) used different types of faces (Male vs Female) with different facial characteristics (dark beard and dark hair vs lighter hair). Also it is possible that the infants' responsiveness has been affected by the larger number of different comparison stimuli (Greenberg and Blue, 1977). Similarly, Bushnell's (1982) use of colour slides could have accounted for his results. Even if there was no such effect, the discrimination reported would be confined only to photographed faces. Also Maurer and Salapatek (1976) whose 1 month-old subjects fixated longer the chin and the hairline used more strange male faces than females (n=2). In addition they adopted a long (75 sec) successive stimulus presentation rather than paired comparisons.

The finding that 1 month-old infants were incapable of discriminating between the profile poses of their mother and that of a female stranger could be attributed to the insufficiency of familiarity with this pose rather than to the absence of the capacity to extract invariant information across poses, or to the inability to remember the mother's face. Since the profile pose of the mother's face is less encountered in daily face-to-face interaction, it is more likely that the aspects characterizing the profile pose have not yet been abstracted.

The suggestion that by 1 month -at least under the present experimental conditions- infants might have had less experience with the profile pose is supported in part by the positive significant correlations between the age of the subject at testing and the extent of preference for the en face and 3/4 profile poses. Both the en face and the 3/4 profile poses had been learned even by the youngest subjects, and the infants' performance increased with increasing age. In the profile pose condition, age had no effect. Preference for the profile face of the mother did not increase with increasing age.

It is not surprising to find that differentiation of the en face and 3/4 profile increases with age since one would assume that infants must have some period of dealing with a class of faces before the distinctive features of that class can be detected and abstracted to form a class concept and it is more likely that highly familiar instances (poses) might be discriminated from novel ones earlier than 1 month. That exposure to multiple instances of the same face during familiarization appears to facilitate the abstract process was noted by Fagan (1976).

The relationship between the infant's birth weight and preference for the mother's face was not significant, indicating that the amount of preference for the mother's face did not significantly increase with increasing birth weight. This result could be due to the design of this research which tested only babies weighing more than 2.650 kg. Perhaps if the samples contained extremely low birth weights, then the effect of birth-weight would be obvious. Findings on low birth weight children shows that significant impairment in IQ occurs largely among children with extremely low birth weight, that is under 3.5 pounds (Kopp, 1983).

Conclusion

The results of this experiment demonstrated the ability of 1 month-old infants to recognize the en face and the 3/4 profile poses of the mother's face, even when the comparison stimulus faces were matched in terms of facial brightness, hair colour and hair length. This recognition suggests the presence of a long-term retention. By 1 month, infants might have combined the en face and 3/4 profile poses of the mother's face, already learned, into a single perceptual category.

The infants failure to recognize the profile pose of their Mother's face indicate that the profile pose of the mother's face is still stored in the infant's mind as a separate face. To conclude, 1 month old infants are better than neonate infants in that they have, to some extent, built up a mental representation of the mother's face which include both the en face and the 3/4 profile poses, but they still deal with the profile pose of the mother's face as a different mother or perhaps a different person.

Experiment 6.3. Recognition of the mother's face viewed in 3/4 profile and profile poses by 3 month-old-infants

Introduction

In the previous experiments of this chapter newborn infants failed to discriminate between the faces of their mother and that of an adult female stranger presented in 3/4 profile poses, and 1 month-old infants, while proving to be capable of recognizing the 3/4 profile pose of the mother and still holding preference for the en face pose of the same face, seemed to have not yet learned the profile pose. A conclusion drawn from the results was that infants might have combined the en face and 3/4 profile poses into a single 'perceptual category'. The profile pose is still learned as a separate face. The conceptual representation of the mother's face, including the ability to extract invariance across changes in poses, requires different levels of abstraction and experience is an important determining factor.

Aim

The present experiment was designed to test 3-month-old infants' ability to recognize both the 3/4 profile and profile poses of their mother's face. More specifically, the aims were to see whether infants have formed one concept for the mother's face or they are still recalling representations of different faces of the mother, and to find out whether infants are able to extract the invariant information with increasing age. The en face pose was not included in this study as both newborn and 1-month-old infants have demonstrated recognition of the mother's face viewed in this pose, and to reduce the number of comparison stimuli which may affect the performance of the infants (Greenberg and Blue, 1977). Since Lewis (1972) reported that mothers of 3-month-old females vocalized significantly more to their infant than mothers of 3-month-old males and noted superiority on the part of females it was decided to include sex as a factor.

To provide a control on the observer's visual fixation recording, it was decided to test half of the subjects by one naive exprimenter and the other half by the author.

Method

Subjects

These were 14 (7 male and 7 female) full terms, healthy infants with no obvious problems both at birth and at the testing time, with normal Apgar scores after birth (Mean Apgar at 1 minute after birth was 8.43, sd = 0.9 (range 7 - 10)mean Apgar at 5 minutes after birth was 9.5, sd = 0.73, (range 8 - 10). Their mean age was 13.08 weeks

(3.1 months), sd = 0.34 (range 11 to 14.4 weeks). The difference in age between males and females was not significant ($t = 0.11$, $df = 12$, NS) by t-test. Their mean birth weight was 3.35 kg, sd = 0.38 (range 2.80 kg - 3.83 kg). The difference in birth weight between males and females was not significant ($t = 0.36$, $df = 12$, NS). Table 6.3.1 shows the subjects' sex, age, birth weight and Apgar scores.

Of the 14 subjects, the birth method of 8 was normal (SVD), 3 were sectioned (LUSCS) and 3 were forceps delivery (MCFD). Experiment 2.1 (method section) provides the explanation of these terms
A further 6 infants were tested, but excluded from the sample because of side bias in their looking behaviour ($n = 3$) or because the mother laughed during testing ($n = 1$) or tried to attract their infant's attention ($n = 2$).

The subjects were volunteered by their parents who were contacted first in the maternity hospital, after the birth of their infant and second prior to the testing.

Table 6.3.1 Subjects' sex, age, birth weight and Apgar scores (N=14)

Ss	Sex	Age (weeks)	Birth weight (kg.)	Apgar at 1min	5mins
1	M	12.5	3.19	7	8
2	M	12.6	3.75	10	10
3	M	13.0	3.57	9	10
4	M	13.1	3.70	8	9
5	M	13.2	3.41	8	9
6	M	13.4	3.68	9	10
7	M	14.0	2.80	9	10
8	F	11.0	2.81	9	10
9	F	12.2	3.41	8	10
10	F	13.0	3.83	9	10
11	F	13.2	2.86	7	9
12	F	13.3	3.78	9	10
13	F	14.3	2.82	9	10
14	F	14.4	3.29	7	8
Mean		13.08	3.35	8.43	9.5
Sd		0.8	0.38	0.9	0.73

Stimuli

The faces that the infants viewed were the real faces of their own mother and of an adult female matched as closely as possible for hair colour, hair length and facial complexion. The faces were presented in 3/4 profile and profile poses. In the 3/4 profile condition, the faces were turned away from the en face pose by 45° towards the centre of the screen. The stimulus faces were asked to look at the edge of the window of the screen to maintain the 3/4 profile pose and ensure it did not vary during testing. In the profile pose condition the stimulus faces were turned away from the en face pose by 90° towards the centre of the screen. Both the mother and stranger were asked not to turn their eyes in the direction of the infant while maintaining the poses. As there were two trials in each condition, each face was shown once to each side of centre. Also, each face was presented both in left and right profiles. A different female non-parturient stranger was used for each subject, but in both conditions.

Apparatus

The apparatus was the same as in the previous experiments.

Procedure

The same procedure was used as in experiment 6.2 with infants being brought by taxi to the Developmental Laboratory, except that an additional observer was used to record the visual fixations.

Results

The fixation times available were expressed into percentages prior to analysis. The data are shown in Table A below. Table 6.3.2 presents the preferences ~~of~~ FOR the mother. Figure 6.3.1 illustrates the percentage preference for the mother and the stranger.

Table A Percentage fixation times (in seconds) for the mother and the stranger (3/4 Profile pose)

	Trial 1		Trial 2		Combined trials	
	Stranger	Mother	Stranger	Mother	Stranger	Mother
Males						
	29.00	71.00	40.00	60.00	34.50	65.50
	74.00	26.00	33.50	66.50	53.75	46.25
	40.50	59.50	92.50	7.50	66.50	33.50
	27.50	72.50	66.50	33.50	47.00	53.00
	0.00	100.00	14.00	86.00	7.00	93.00
	0.00	100.00	0.00	100.00	0.00	100.00
	30.50	69.50	44.00	56.00	37.00	62.75
Female						
	56.50	43.50	5.00	95.00	30.75	69.25
	100.00	0.00	51.00	49.00	75.50	24.50
	79.00	21.00	46.00	54.00	62.50	37.50
	32.50	67.50	34.85	65.15	33.75	66.25
	23.00	77.00	15.50	84.50	19.25	80.75
	60.50	39.50	37.50	62.50	50.00	50.00
	73.50	26.50	23.00	77.00	50.00	50.00

Only the en face data are given

Table 6.3.2. Mean percentage preference for the mother's face across Sex, Poses and Trials

		3/4 Profile		Profile		Ave.
		Trial 1	Trial 2	Trial 1	Trial 2	
Sex	Males	71.2	58.5	67.0	77.7	68.6
	Females	39.2	69.6	57.4	57.4	55.9
	Average	59.6		64.9		

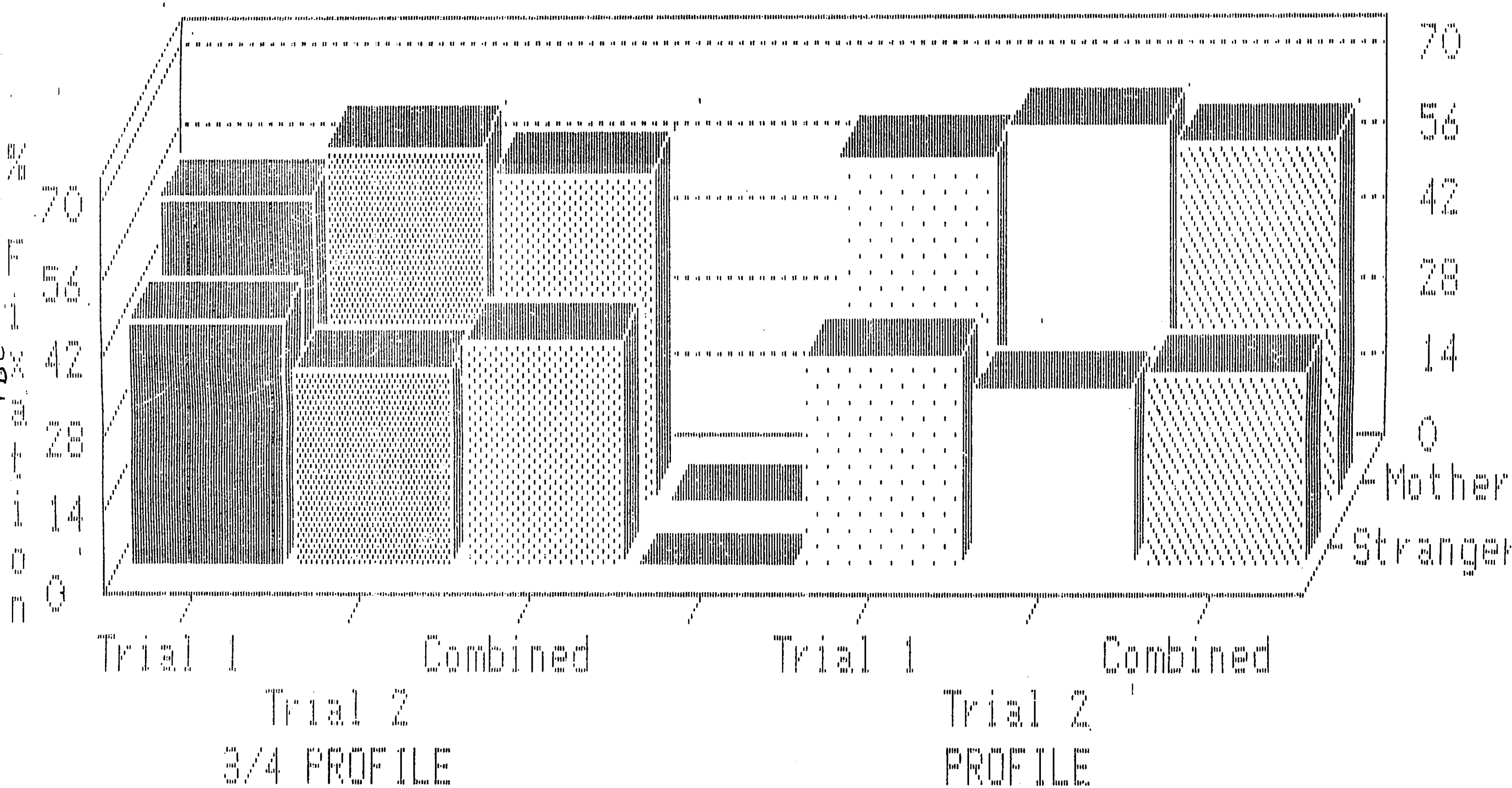


Figure 6.3.1 Percentage preference for the mother and the stranger across poses (3/4 profile and profile).

Preference for the mother's face across Sex, Poses and Trials

A three way Anova incorporating one between subjects factor, Sex (Male, Female) and two within subjects factors, Pose (3/4 Profile and Profile) and Trials (Trial 1, and Trial 2). No main effects of Sex ($F(1,12) = 1.48$, NS), Poses ($F(1,12) = 0.81$, NS) and Trials ($F(1,12) = 3.38$, NS) approached significance though males fixated their mothers more ($M = 68.6$) than females did ($M = 55.9$) and infants looked at the profile more ($M = 64.9$) than at the 3/4 profile poses of the mother's face ($M = 59.6$). These means are shown in Table 6.3.2.

Also, the interactions of Sex and Poses ($F(1,12) = 0.15$, NS) and Poses and Trials ($F(1,12) = 0.09$, NS) were not significant, but the Sex x Trials ($F(1,12) = 4.38$, NS) interaction just failed to reach significance. Table 6.3.3 presents the Anova summary table.

The only interaction to attain significance was that of Sex x Poses x Trials ($F(1,12) = 6.05$, $p < 0.05$). A multiple t ratio were used to compare the means which led to this effect. On Trial 1, males looked more at their mother's 3/4 profile face ($t = 2.92$, $df = 12$, $p < 0.01$, one-tailed) than females did on the same Trial, and also at the mother profile pose on Trial 2 ($t = 1.86$, $df = 12$, $p < 0.05$ one-tailed) than did females did. While females fixated the 3/4 profile pose of their mother's face more on Trial 2 than males ($t = -1.01$, $df = 12$, NS), male infants looked more at the profile pose of their mother's face ($t = -0.87$, $df = 12$, NS) the difference was not sufficiently large to reach significance. Females preferred the 3/4 profile pose of their mother more on Trial 2 than on Trial 1 ($t = -2.77$, $df = 12$, $p < 0.01$. one-tailed) but no significant differences were found in the visual fixations to the mother across trials ($t = 0$, $df = 12$, NS) in the profile pose. Males, however, showed no differential preference across Trials in the 3/4 profile pose ($t = 1.16$, $df = 12$, NS) and in the profile pose ($t = -0.98$, df = NS). They looked at their mother longer on Trial 1, in the profile pose condition ($t = 2.53$, $df = 12$, $p < -.025$, one-tailed) than females did in the 3/4 profile on the same trial, but no significant differences were found between males' performance in the 3/4 profile pose condition and females' preference for the profile pose on Trial 1 ($t = 1.26$, $df = 12$, NS) and on Trial 2 ($t = 0.09$, $df = 12$, NS) and between males' preference for the profile pose of the mother's face and females preference for the 3/4 profile pose of the mother on Trial 2 ($t = 0.74$, $df = 12$, NS).

Table 6.3.3. Preference for the mother's face across Sex (Male and Female), Poses (3/4 Profile and Profile) and Trials (Trial 1 and Trial 2)

	Sum of Squares	Df	Mean Square	F. Ratio	P. Value
Sex	2251.7144	1	2251.7144	1.4813	0.245061
Sex x subj. Error	18241.3343	12	1520.1112		
Poses	386.4001	1	386.4001	0.8171	NS
Sex x Poses	71.7779	1	71.7779	0.1518	NS
Sex x Poses x Error	5674.6058	12	472.8838		
Trials	702.9028	1	702,9028	3.3857	0.086098
Sex x Trials	911.2645	1	911.2645	4.3894	0.054152
Sex x Trials x Subj. Error	2491.2914	12	207.6076		
Poses x Trials	40.9717	1	40.9717	0.0981	NS
Sex x Poses x Trials	2529.9456	1	1529.9456	6.0549*	0.027457
Sex x Poses x Trials x Subj. Error	5014.0414	12	417.8368		

* $p < 0.05$

To determine the extent of preference for the mother's face in the 3/4 profile and profile poses, correlated t-tests were computed to compare the fixation to the mother with that to the stranger on Trial 1, Trial 2 and on both Trials combined. In the 3/4 profile condition, the difference on Trial 1 ($t = -0.65$, $df = 13$, NS) and on the combined Trials ($t = -1.62$, $df = 13$, NS) were not significant. Only on Trial 2 was preference for the mother significant ($t = -2.1$, $df = 13$, $p < 0.05$, one-tailed).

Similarly, in the profile pose condition, the preference for the mother's face was not significant on Trial 1 ($t = -1.75$, $df = 13$, NS), but the 3 month-old infants fixated their mother significantly more than the stranger on Trial 2 ($t = -2.52$, $df = 13$, $p < 0.025$, one-tailed) and on the Combined Trials ($t = -2.41$, $df = 13$, $p < 0.025$, one-tailed). Tables 6.3.4 and 6.3.5 present the means. The t-values are shown in Table 6.3.6.

Table 6.3.4. Mean percentage preference for the 3/4 profile pose of the mother's face on Trial1, Trial 2 and on the Combined Trials

	3/4 Profile		
	Trial 1	Trial 2	Combined Trials
Mean			
Standard Deviation	29.98573	24.60072	21.81129
Variance	899.1442	605.1956	475.7325
Averge deviation	25	17.975	17.33929
Coefficient of Variance	54.27282	38.41076	36.69067

Table 6.3.5. Mean percentage preference for the profile pose of the mother's face on Trial 1, Trial2 and on the Combined Trials

	Profile		
	Trial 1	Trial 2	Combined Trials
Mean	62.2	67.6	64.9
Standard Deviation	26.05668	26.02248	23.13373
Variance	678.9505	677.1693	535.16939
Average deviation	23	19.64796	18.04082
Coefficient of Variance	41.88215	38.50089	

Table 6.3.6. One-tailed tests for preference for the mother across poses and Trials in 3 month-old infants

		Df	t	P-Value
	Trial 1	13	-0.65	NS
3/4 Profile	Trial 2	13	-2.13	$p < 0.05$
	Combined Trials	13	-1.62	NS
	Trial 1	13	-1.75	NS
Profile	Trial 2	13	-2.52	$p < 0.025$
	Combined Trials	13	-2.41	$p < 0.025$

The relationship between the infant's birth weight and extent of preference for the mother

Pearson's Product-Moment Correlations were used to assess the relationship between the infant's birth weight and extent of preference for the mother's face and negative non-significant correlations were found both in the 3/4 profile ($r = -0.027$, NS) and in the profile pose conditions ($r = -0.14$, NS), indicating that preference for the mother at 3 months of age is negatively correlated to the birth weight of the subject. Heavier infants at birth were no better than lighter ones.

The relationship between the infant's age at testing and extent of preference for the mother

The relationship between the age of the infant at testing and the extent of preference for the mother over the combined trials was assessed by Pearson's-Product-Moment Correlations and a negative non-significant correlation was found in the 3/4 profile pose condition ($r = -0.25$, NS) and a positive non-significant correlation was obtained in the profile pose condition ($r = 0.37$, NS), indicating that the extent of preference for the mother is not affected by the increasing age of the infant.

Comparability of results across observers' recordings

To determine the comparability between the two observers who recorded the visual fixations, a two-way-Anova was computed using percentage preference for the mother, with one between subjects factor, Observer (Observer 1, Observer 2) and one within subjects factor, Poses (3/4 Profile, Profile). There were no main effects of Observer ($F(1,12) = 0.21$, NS) or of Poses ($F(1,12) = 0.90$, NS). The interaction of Observer with Poses ($F(1,12) = 0.10$, NS) also did not attain significance (Table 6.3.7 shows the means). The Anova summary table (6.3.8) presents the data.

Table 6.3.7 Mean percentage preferences for the mother across Poses and Observers

		3/4 Profile	Profile	Ave
	Observer 1 (Author)	62.9	66.5	64.7
Observer	Observer 2 (Naive)	55.9	63.3	59.6
	Average	59.4	64.9	

As can be seen from tables 6.3.7 and 6.3.8 there was no significant difference between the recordings of the two observers, though this analysis did not test the reliability, but tested for an effect of naivety. Interobserver reliability has been found to be uniformly high by a number of investigators who employed the same criteria as the present study for measuring differential fixations (see the review by Fagan, 1973). Recently, Kleiner (1987) found a high interobserver correlation across conditions (r=0.81. In a second study by Kleiner & Banks (1987) the interobserver agreement was higher (r=0.87).

Table 6.3.8 Preference for the mother across Poses and observers

	Sum of Squares	Df	Mean Squares	F. ratio	P. value
Observer	180.0357	1	180.0357	0.2127	NS
Observer x Subj. Error	10155.0714	12	846.2560		
Poses	209.0089	1	209.0089	0.9017	NS
Observer x Poses	25.0804	1	25.0804	0.1082	NS
Observer x Poses x Subj Error	2781.5357	12	231.7946		

Since the present chapter has examined the development of the capacity to extract invariant information across different poses of the mother's face and all experiments used similar methodology, the preference data for the 3/4 profile pose could be compared across age groups. The en face and profile poses were not included because newborns were tested only for their response to the 3/4 profile pose and 3 month-olds were not examined on the en face condition. To study the Sex effect in a larger sample, Sex factor was also incorporated. The two-way-Anova, using percentage preference for the mother, considered two between subjects factors, Sex (Male, Female) and Age group (Newborns, 1 month, 3 month-olds). None of the variables attained significance, indicating that there was no difference between younger and older infants in responding (Age ($F(1,30) = 1.06$, NS), nor was there any significant sex effect ($F(1,30) = 0.51$, NS). The Sex x Age interaction effect ($F(1, 30) = 1.85$, NS) was also not significant suggesting no significant differences in preference for the 3/4 profile pose of the mother's face between males and females across age. However, preference seems to attain its peak around 1 month and to decrease slightly afterwards (Table 6.3.9 illustrates these means and Table 6.3.10 presents the Anova summary table).

Table 6.3.9 Mean percentage preference for the 3/4 profile pose across Sex and Age (newborn, 1month and 3 month olds)

		Age Group			
		Newborns	1 month	3 month	Ave
Sex	Male	41.6	63.3	65.2	56.7
	Female	63.7	66.6	54.7	61.7
	Ave.	52.6	64.9	59.9	

Table 6.3.10 Preference for the 3/4 profile pose of the mother's face across Sex (Male, Female) and Age (Newborns, 1 month- and 3 month-olds)

Source	Sum of Squares	Df	Mean of Squares	F.ratio	P.value
Sex	221.5135	1	221.5135	0.5124	NS
Age	919.7042	2	459.8521	1.0638	0.358784
Sex x Age	1600.2419	2	800.1209	1.8509	0.171609
Sex x Age x Subj. Error	12968.4834	30	432.2828		

Discussion

The present results indicate the ability of 3 month-old infants to recognize the profile pose of their mother's face. Though the faces of the mother and the stranger were matched as in the previous study) as closely as possible for hair colour, hair length and facial brightness, and their olfactory cues were masked, 3 month-old infants showed a limited evidence of a preference for the 3/4 profile pose of the mother.

The fact that infants looked almost equally to the stranger and the mother on Trial 1 and on the Combined Trials in the 3/4 profile condition suggests that at 3 months while some infants are still responding with preference for familiarity (mother), others have started preferring novel faces. This decrement in preference for the mother's 3/4 profile pose around the third month is consistent with those of Wetherford and Cohen (1973), who reported a decrease in 10 and 12 week-old infants' response to the familiar stimulus over trials. Perhaps the decreased fixations of the 3 month-old infants were instances of habituation. However, Jeffrey and Cohen (1971) argued that a response decrement alone is insufficient evidene of habituation; recovery to a novel stimulus is necessary in order to rule out situational and fatigue effect. Since preference for the novel pose was not significant in the present experiment with infants showing equal amount of fixations, greater caution should be used in interpreting these results.

With repeated exposure to the mother's face, the infant comes to learn the specific features that distinguish the mother's face from other faces (E. Gibson, 1969). To detect the invariant features across poses, the infant must have a mental representation (Kagan, 1979) at least of the mother's face. The present results indicate that by 3 months, the infant certainly can store some kind of abstract copy of the mother's face and of a transformation of that face. The 3 month-olds' ability to recognize the mother shown in 3/4 profile and profile suggests some understanding of the existence of a single mother in different orientations. As the memory representation becomes more and more complete, the separate faces are combined into a single perceptual category.

It is however, not surprising to find that differentiation of faces does not increase with age since by 3 months the mother's profile pose was learnéd even by the youngest infants. Since the 3/4 profile pose is learnt earlier than the profile one, the older infants could have started responding to the novel face, whereas the youngest were still holding preference for the 3/4 profile pose of their mother's face.

Similarly, the non significant relationship between birth weight and extent of preference for the mother's face suggests that birth weight is a poor predictor of the amount of preference for the mother's face, at least in the present research which used babies weighing not less than 2.60 kg. A study comparing low birth weight and normal birth weight infants would be required to find out the effect of birth weight on the amount of preference for the mother's face.

No main effect was found for sex but male infants tended to fixate the profile pose of their mother's face longer. This result does not agree with Lewis's (1972) finding that 3 month-old females are more responsive to the mother's en face pose than males. But it is consistent with Watson et al's (1979) data that male infants between 14 and 20 weeks of age smiled longer at their mother than at the stranger when both faces were presented in the 90^{o} orientation, but failed to discriminate between different orientations of their mother's face.

As far as the comparability of the observer's recordings is concerned, each of the two observers tested one group of infants. There was no difference between the two groups' performances, though one of the observers was blind as to the identity of the stimulus faces and the hypothesis being tested. This result indicates once more that the observer did not bias the results.

Conclusion

Overall it may be concluded that 3 month-old infants, under the present experimental procedures were able to recognize the profile pose of their mother's face, and detect invariant information. Discrimination of the mother was obtained even when the colour of the faces and colour of the hair were matched in terms of brightness which standardized the level of contrast across the comparison faces, and olfactory cues were controlled.
The limited evidence of a preference for the 3/4 profile pose of the mother demonstrated by 3 month old infants, perhaps indicates that at this age they have already learned this pose and are starting to respond to novel faces of the same category (females).

By the third month infants appear to have abstracted some basic differentiating features of the mother's face. Whether infants of this age store a single concept for the mother's face or they store information non systematically and recall representations of different faces, is a question which this study cannot answer. Experience with the mother's face is necessary for the establishment of one representation of the mother's face.

General Discussion

One of the primary objectives of this series of experiment was to determine if young infants can extract invariant information across various poses of the same comparison faces, and whether there were differences in the infants' capacity to process invariance as a function of their age. A hypothesis raised in the introduction of this chapter was that the ability to recognize the mother's face displaying static expressions implies the existence of the processing at least of some level of invariance across presentations and time during the neonatal period.

The present research provides the first direct evidence of the inability of newborn babies to recognize the mother's face seen in a pose (3/4 profile) other than the en face pose. The 3/4 profile pose was however recognisable by 1 month-old infants who also maintained a preference for the en face pose of the mother's face, but failed to recognize the profile pose of the same face. By the third month, infants seemed to have learned the profile pose, although there was only limited evidence of preference for the 3/4 profile pose. Thus, newborn infants are perceptually different from both 1 month- and 3 month-old infants at least under the present experimental conditions, when faces are subjectively judged by the experimenter as quite similar in terms of facial brightness.

The present data suggests that dramatic changes in processing information about faces take place between 1 and 3 months as a result of increasingly varied experience with a particular face and the development of representational capacities. By 1 month, infants seem to be capable of differentiating between two faces (3/4 profile poses) from the same category (adult female with the same facial brightness and hair length). However, at this age the infants appear to have constructed a fairly narrow category, namely the mother's face in a particular orientation, and this is the reason why they failed to recognize the mother's face in the profile pose. The same face, in a completely novel pose, paired with a novel face was treated by 1 month-olds as equally unfamiliar. With increasing experience with the mother face, infants store different facial aspects of their mother's face in memory. The storage becomes more and more complete and a broader concept of the mother's face is constructed, not a particular mother in a particular orientation, but "the Mother" irrespective of orientation, that is one mother in different poses, not several mothers. The varied experience with different poses of the same face led the 3 month-old infants to attenuate or delete orientation as a salient feature in identifying the unique aspects of the mother's face. Narrow experience with respect to orientation made neonates pay more attention to change of orientation. During the discrimination task, the infant compares the novel face to the prototype built up and in particular to the more broadly represented features in the prototype. The 3 month-olds' capacity to recognize the mother viewed in the profile pose could suggest the presence of a conceptual representation of the mother's face. Their limited preference for the 3/4 profile pose could be interpreted on the basis that infants may acquire different levels of concepts depending on the amount of experience they have had. This may be similar to Cohen and Strauss (1979) reporting that 30 week-olds construct different levels of concept according to which habituation condition they received.

The construction of concepts especially the conceptual representation of the mother's face indicates that the infant has learned some of the unique aspects of the mother's face that remain invariant over different poses. However, learning relies on both habituation and conditioning which in turn imply infant memory. An infant habituates to a face because the face is becoming more familiar. For it to be familiar, it must be in some way remembered. The questions that araise here: how long can an infant remember? Whether that memory is subject to interference? Is the same type of information retained in long-term as well as in short-term memory?

Evidence suggesting that the newborn infant is capable of habituation (Engen et al., 1963; Engen and Lipsitt, 1965; Keen et al, 1965; Friedman and Carpenter, 1971;

Friedman, 1972; Friedman et al 1974; Field et al, 1984) was obtained in laboratory experiments, where a control over the parameters of stimulation was exerted, and the stimulus presentations were limited to a single infant state, habituation was likely to proceed more efficiently (Engen & Lipsitt, 1965; Engen et al. 1963). Cohen and Gelber (1975) and Cohen (1976) indicated that infants as young as 2 months can habituate to a repeated visual stimulus and dishabituate to a novel one. At 4 or 5 months of age infants can retain previously encoded visual information for minutes and even weeks. This evidence perhaps helps to explain why 1 and 3 month-olds in the present research showed familiarity preference instead of novelty. The familiarity effect was not transferred to other faces as in Fagan (1976) and Cohen & Strauss (197() among others. Perhaps infants have demonstrated a long-term memory effect. They might have associated the pleasurable experience with the mother's face. Another interpretation is that the familiarity preference could be attributed to the procedures adopted.

In chapter 5, two approaches to the detection of invariance were reviewed. While the Gibsons emphasis is on the extraction of invariants that are actually present in the pattern of stimulation, Kagan argues that similar stimuli are referred to some common prototype which may in some way go beyond or abstract from the actual pattern of stimulation.

The finding that neonates were not able to recognise the 3/4 profile face of the mother confirms Gibsons' view that only with repeated exposure to an object does the infant become better able to detect those features that differentiate that object from other objects and those features that distinguish between various members of the same class.

Since neonates, at birth, have limited experience with the 3/4 profile pose of the mother's face, they fail to recognise the mother. Similarly, 1 month-olds were not capable of recognizing a pose which they had experienced less. Thus, Kagan's assumption that in the first months of life attention is controlled by the physical aspects of the stimulus itself rather than by any stored experience with the stimulus is weak. The present results indicate that experience plays an important role in early face recognition and in the processing of invariance.

The neonates' inability to recognize the mother's face shown in 3/4 profile is consistent with E.Gibson's suggestion that at birth the infant is incapable of discriminating the distinctive features and that gradually the infant would attend to those features while ignoring those that remain constant across faces. The question that arises here is how the infant knows what stays constant and what varies across poses?

To recognize the invariant features, the infant must have an internal representation to compare what is being seen to what was experienced in the past. Certainly experience with a pose is necessary for learning the particular features that distinguish a face but, the detection of invariant properties of a face despite a change in orientation requires the presence of an internal representation of that face in that particular pose. Thus, one would insist on the relative contribution of experience and of a mental representation for the detection of invariance.

The finding that 3 month-olds were able to recognise the mother's face shown in 3/4 profile and profile poses indicates that by this age, the infant has built up an internal representation of the mother's face. This result agrees with Kagan's assumption that between 3 to 7 months the infant develops mental schemata.

The presence of some representational capacities can be suggested even at the age of 1 month as Experiment 6.2 indicated. The 1 month olds' ability to recognise the mother's 3/4 profile face suggests that at this age the infant is able to represent at least a slight transformation of the mother's face and store some kind of abstract copy of that transformation.

The results of Experiment 6.3 accord well with Kagan's suggestion that the infant's attention tends to be prolonged to those events that are a little different but not extremely different from the one that created the original schema.

As far as sex differences in the present set of experiments are concerned, no significant differences between males and females were found, neither in the neonatal period, nor at 1 and 3 months of age. This result is inconsistent with the finding of Lewis (1972) that 3 month-old-females are more responsive than males and Watson et al's (1979) finding that 20-week female infants were superior to males in differentiating between their mother and a distinctive stranger when both faces were paired with their own. The males failed even to discriminate between different orientations of their mother's face.

Though the 3 experiments of this chapter tested few subjects, the results support the hypothesis that sex effect is not consistent. The social experiences afforded to infants during the early months of life have been suggested as a source of sex difference by Moss (1967); Goldberg & Lewis (1969); Moss, Robson & Pederson, (1969), Rebelsky & Hanks (1971). Of course, the question of social experiences and cultural percepts of the parents as a potential source of sex differences raises a potentially fruitful area for further research.

Conclusion

These 3 experiments indicate that while neonates are unable to recognize the mother's face seen in a pose other than the en face pose, 1-month olds were capable of recognizing only the 3/4 profile pose. Three-month-olds however, though successfully discriminated the profile pose of their mother's face, showed only limited evidence of a preference for the 3/4 profile pose which 1-month-old recognized easily.

These results seem to suggest that the ability to detect invariant information develops in the first 3 months of life at least when tested under the present experimental procedures. By the first month, infants appear to learn facial poses as 'separate faces', later, around the third month, these faces are perhaps combined into a single perceptual category. This suggestion is based on the finding that 3 month olds looked more at the profile pose of their mother than at that of a strange female, even when the two faces were matched as closely as possible for hair colour and length and facial brightness.

Chapter 7

AN OBSERVATIONAL STUDY ON THE TOTAL AWAKE TIME SPENT IN FACE-TO-FACE INTERACTION WITH THE MOTHER IN THE NEONATAL PERIOD.

Introduction

In order to determine the extent of the infant's opportunity to learn details of its own mother's face, it was decided to conduct an observational study. This study involved examining a number of mother - infant pairs over the first few days-of-life.

From existing information about early attachment information, it is evident that face-to-face episodes are considered to play a fundamental part in developing attachment.

1.1 Eye-contact

Certainly in early mother-infant interaction, mutual gazing or eye-to-eye contact is extremely important to the mother for various reasons. Klaus et al. (1970) reported that eye contact helps mothers feel closer to their newborn babies. In this study, the investigators observed a group of full term and another of preterm babies during the first contact after delivery. The mothers of full terms were filmed from 30 minutes to 13 hours after delivery (Mean = 5.3 hrs). The second group of mothers was filmed one to three days after delivery (Mean = 1.2 days). Various infant and maternal behaviours were recorded (e.g. mother smiling, physical support, movement of infant, looking behaviours etc.). Also, the amount of time spent in face-to-face interaction was measured. It appeared that mothers vocalized to their infants in order to see their eyes as this seemed to arouse their positive feelings for the baby. For example, the mothers would say: "Open your eyes and if you open your eyes, I will know you are alive" Klaus et al., 1970, p.72). The amount of time the mother spent looking at their full term babies en face increased from 10% in the first 3 minutes to 23% in the last 3 minutes of a ten minute session. These findings suggest that behaviours which promote maternal attachment are not only established in the first hours following the infant birth but they also increase with time.

For Klaus et al. (1970) the large amount of time that mothers spent in face-to-face interaction with their infants and their verbally expressed interest in the infant's eyes agree with Robson's (1967) proposition that eye contact is one of the releasers of maternal caretaking behaviour. The infant's eyes seem to be an important mediator of interaction. Complementing the mother's interest in the infant's eyes is the early functional development of its visual pathways, enabling it to look at and follow the human face in the first hour of life (Brazelton et al., 1966).

In addition, the eyes as distance receptors (Walters and Parke, 1965) allow visual interaction to occur more often, particularly when the mother is in physical contact with her baby. Brown et al.'s (1975) study of 30 minute observation sessions which consisted of brief feeding episodes (11 mins)) indicated that during rubbing (6 minutes (21%), kissing, rocking their newborn babies, the mothers and infants were visually interacting. In Osofsky's (1976) study neonates looked at their mother more during feeding. Thus, physical contact helps both the mother and infant to maintain visual contact. Accordingly, caring mothers who attend more to their infant and mothers of first born infants who lack experience and take longer in caretaking activities would be expected to have more visual interaction than mothers who do not often come into contact with their infants.

Visually attentive mothers tend to have infants who are visually attentive. Osofsky and Danzger (1974) and Osofsky (1976) reported that, in the neonatal period, the more alert infants received more visual stimulation during feeding or in other stiuations. The mothers who stimulated their infants less, their infants tended to have their eyes closed (Brown et al., 1975).

The mother is a major mediator of stimulation too. The mother's visual regard can affect the neonate's visual behaviour and establish eye-to-eye contact. Osofsky and Danzger (1974) and Osofsky (1976) found that the mothers who gazed longer at their infant, their infant tended to look more at them ($r = 0.28$, $p < 0.05$).

1.2 Vocalization

Certain maternal behaviours have been found to be related to infant vocalization. Brown et al. (1975) who observed neonates on their third day of life during two 1/2 hour sessions in which the mother bottle fed her infant, found that the more the infant vocalized, the more their mothers looked at them and spent more time in caretaking. Maternal attentiveness and general sensitivity during feeding were related to the infant's auditory responsiveness. Of interest is the fact that the mother's tactile stimulation related positively to infant's auditory production ($r(132) = 0.36$, $p < 0.01$). Overall the mother - infant contact during feeding interaction was frequently in the auditory domain.

In Osofsky's (1976) study neonates and their mothers were observed between the second and fourth day of the infant's life. The first behavioural obervation was after a scheduled feeding time, the second one took place for about 15 mins. between 1 1/2 and 2 hours after the scheduled feeding. Neonates responded more to auditory stimulation, but it took them longer to habituate to the sound of shaking a rattle. These findings replicate those of Osofsky and Danzger's (1974).

Similarly, Bakeman and Brown's (1977) findings indicated that mothers vocalized to their 1/3 day old infants (10.8%) for almost the same amount of time as the neonates vocalized (10%) to them. The subjects were observed for two 1/2 hour sessions, one at noon and the other at 4.00 p.m., during which the mother bottle fed her infant.

1.3 State of the infant

The infant state as an important variable in mother - infant interaction has been stressed by Levy (1958), Yarrow and Goodwin (1965), Moss (1967) Brazelton (1961), Jones and Moss (1971), Lewis (1972), Ashton (1973) and Korner (1973, 1974). The state of the infant reflects his needs as well as the availability of the infant for contact with the mother particularly in the infant for ~~contact with the mother particularly in the visual and~~ auditory domains. An alert infant is generally very receptive to interaction with the mother. Studies by Korner on neonates revealed significant differences among newborns in how frequently they spontaneously alert (Korner 1970) and how readily they respond with alertness to different types of maternal ministrations (Korner & Thoman, 1972). The more alert infants received more visual stimulation during feeding ($r = 0.31$, $p < 0.05$).

Evidence from the literature, demonstrated that the amount of maternal contact positively varied with the infant's irritability (Moss, 1967). Through crying babies are good elicitors of maternal attention. In one study by Korner (1971) it appeared that babies differ significantly from each other in the frequency with which they provoke such attention. Sleeping and waking states of 2 to 3 day-old bottle-fed neonates during four 1/2 hour periods over two feeding cycles were monitored. Frequency and durations and regular sleep, irregular sleep, drowse, alert inactivity, waking activity and crying were recorded.

Differences among neonates both in how frequently and how long they cried ($p < 0.01$ and, < 0.05, respectively) were found. Also differences among newborns were noted in durations of waking activity ($p < 0.01$), the frequency in shifts in states ($p < 0.01$) and the frequency of global and of diffuse motions ($p < 0.01$) for both. Long wakefulness and a high degree of restlessness no doubt evoked more frequent interactions with the mother than quiet sleepiness.

Not only does the infant's general arousal, and particularly his irritability, have an effect on the mother, the infant's relative soothability does as well. Levy (1958) found differences in maternal greeting responses which varied depending on the state of the infant. During the first week of the infant's life, mothers greeted quiet or awake babies 1/3 of the time. Crying neonates were greeted 1/6 of the time.

1.4 Birth order as an interactive factor

Evidence from a number of studies indicates differences in maternal behaviour during the neonatal period related to the birth order of the infant. Thoman, Turner, Leiderman and Barnett (1970) studied the relationship between mothers and their 2 day-old infant. Primiparous mothers (mother of first borns) and their infants spent more time in the feeding process than multiparous mothers (mothers of later borns) and their babies. In subsequent studies by Thoman, Leiderman and Olson (1972) and Bakeman and Brown (1977) similar results were found.

In another study by Thoman et al., (1971) mother's feedings were compared with nurse-infant feedings of the same infants and no differences were found due to birth order when nurses did the feeding. Birth order differences were however apparent when mothers did the feeding. These findings suggest the importance of birth order factor in early mother-infant contact.

1.5 Infant sex as an interactive factor

Evidence suggests that at a very early age, male and female neonates are treated differently by their mothers. The infant's biological sex seems to exert an influence on maternal behaviour. Studies by Thoman et al. (1971) and Thoman et al. (1972) reported that differences in maternal treatment as a function of the sex of the infant start right after birth. Both primiparous breast-feeding mothers and primiparous bottle-feeding mothers were observed to stimulate, talk, and smile more to female than male infants. This difference was not found in multiparous mothers. Further, mothers of females could more easily calm their babies than could mothers of males after the infant had been crying for a long period of time.

Contradictory evidence has indicated that mothers vocalize more to male infants than to females. Brown et al. (1975) who observed only bottle feeding mothers, found that on average mothers vocalized more to their male infants (13% vs 34%) and spent more time stimulating them (26.2% vs 16.9%). Support for these results comes from a subsequent study by Bakeman and Brown (1977). The male neonates were vocalized to (17.6% vs 4.8%) more than females.

The sex of the infant affected maternal response regardless of the behaviour of the infant. Mothers were more physically affectionate toward their male newborn than toward their female infant. The males were rubbed, patted, touched, kissed, rocked more than were female infants (Brown et al., 1975). The mothers attended more to their male infants than females in Bakeman and Brown's (1977) study. They were rocked, rubbed and patted more (34.5% for males vs 24.7% for females). They even initiated more behaviours which were not essential to the feeding process, and as a result male infants spent less time by themselves. They were always in contact with their mothers on their third day after birth. Bakeman and Brown concluded that mothers responded differently to their infant's sex classification, not that male and female infants behaved differently.

Summary and conclusion

In the above review, relevant aspects of the interaction process between mothers and newborn infants were discussed. The aim was to understand the contribution of the infant and the mother to the early contacts, and in which domain they interact the most. The mother and the newborn infant seem to affect each other through a reciprocal process which of course develops later.

The mother and neonate interact mostly vocally and visually. Maternal behaviours are related to infant vocalizations. The frequency and duration of mother caretaking behaviours varied with the infant's rate of vocalization (Brown et al., 1975). Also maternal attentiveness and general sensitivity during feeding correlated positively with the infant's auditory responsiveness (Brown et al., 1975). Relationships between maternal and infant vocalization were found (Osofsky & Danzger, 1979; Osofsky, 1976). The more the mother vocalized, the more the infant responded vocally (Bakeman & Brown, 1977).

The mother and neonate also interact visually. Eye contact helps in the establishment of the early mother-infant attachment (Klauss et al., 1970). It arouses positive feelings toward the baby. It releases maternal caretaking (Robson, 1967), and it is a mediator of interaction. Maternal attentiveness and general sensitivity toward the infant related to eye contact (Osofsky, 1976).

The availability of the infant for contact is determined by the state of the infant. The more alert infant received more visual stimulation (Korner & Thoman, 1972, Osofsky & Danzger, 1974, Osofsky, 1976). In the neonatal period, infants differed from each other in their alertness and the extent of their responsivity to maternal caretaking behaviours. The amount of maternal contact positively varied with the infant's state, particularly the infant's level of irritability (Moss, 1967) and soothability (Levy, 1958)

The birth order of the infant appears to be an important variable in early mother-infant interaction. Primiparous mothers spent longer feeding their babies than did multiparous mothers. They also were more involved in early face-to-face interaction than were mothers of later born infants (Thoman et al., 1970, Thoman et al., 1971; Thoman et al., 1972). Birth order effects were apparent only when mothers fed their infants, and not when nurses fed the infants (Thoman et al., 1971).

Also differences in maternal behaviours during the neonatal period related to the <u>sex of the infant.</u> Primiparous mothers smiled and vocalized more to their female infants than to their male infants (Thoman et al., 1971, Thoman et al., 1972). Bottle feeding mothers, however, were observed to vocalize more to their male infants than to females (Brown et al., 1975; Bakeman & Brown, 1977). In addition, mothers seemed to be more affectionate towards their male infants and tended to stimulate them more often than females (Brown et al., 1975; Bakeman & Brown, 1977).

In conclusion, it appears that most early mother-infant contacts tend to occur during the feeding process. The mother affects the infant and the infant influences the mother through a reciprocal system. Both the mother and infant vocalize to each other. They interact visually, but eye-to-eye contact is more meaningful to the mother. It is a source of intense pleasure for the mother and a cornertone in the development of attachment to the baby. The state of the infant (alertness, irritability, crying) plays an important role in mother-infant interaction. It elicits and attracts the mother's attentiveness and response. Finally, both the birth order and sex of the infant are predictors of the mother's behaviour.

<u>Summary of aims</u>

In Chapters 2 and 4 it was suggested that neonates may learn some visual aspects of the mother face as a result of continuous interaction between the mother and the baby. A question raised was whether there is a relationship between the total contact hours involved between the mother and the newborn baby and the extent of preference for the mother's face. The answer to this question might help to explain the finding of a non-significant relationship between age and extent of preference; and it will provide in (the context of this Hospital) information about the extent and pattern of exposure to the mother's face, through which the infant comes to learn the specific features that discriminate the mother's face.

The main aim of this study was to determine the total awake time spent in face-to-face interaction with the mother in the time following the first few hours after birth. Is there any relation between the amount of time the infant spends in face to face interaction with the mother and the extent of preference? The results of the present study will be related only to the findings of face recognition which this thesis has demonstrated. Does the duration of contact increase across the first days with increasing age of the infant?

A second aim was to determine the frequency of behaviour to find out which of behaviours mothers and infants are mostly engaged in when they are in contact with each other. It should be noted that the present study was intended as a fact finding exercise, more of an exploration than a definite study.

Method

Since the purpose of this study was to determine the frequency and duration of contacts involved between the mothers and their newborn infants, a time sampling procedure seemed to be a suitable observational strategy to use.

The time sampling technique was adopted in the present study because: 1) It is appropriate because mother-infant contacts are easily observable. 2) It is closely tied to measurement. It allows the observer to tally contacts noting how frequently they occur, or to measure the length or duration of contact. 3) It allows the observer to decide what length, spacing and number of intervals are to be used, these being governed by the purpose of the observation. 4) Finally, it allows the observer to break a larger behaviour unit into component behaviours and specify the observed activities by defining them.

Subjects

1. Mothers

The 9 Caucasian mothers in the sample were all volunteer subjects at the Royal Maternity Hospital, Glasgow, throughout the course of the study. They were all married, and living with their husbands. The mothers were asked to take part in the study immediately after their admission to the post-natal ward following the birth of the infant. All the mothers had what was judged to be a "normal" pregnancy and medical background as indicated by the Obstetricians attending the mothers.

The mean age of the mothers was 28.22 years (range 20 - 39, sd = 5.84). The mothers were working class to middle class according to their own subjective classification. Table 7.1.1 shows the mothers' age and social class.

Table 7.1.1 Mother's age and social class

Ss	Age (years)	Social Class
1	20	M
2	24	M
3	35	W
4	32	M
5	39	W
6	22	M
7	27	W
8	29	M
9	26	M
Mean	28.22	
Sd	5.84	

M: Middle class
W: Working class

2. Babies

The initial sample included sixteen subjects (8 male, 8 female). Seven females were discarded because they were discharged from the hospital before the observational study was completed. The reason behind the earlier discharge of females in this sample is that all females were non-first born babies. Usually, first born babies are kept for longer time in Hospital than non-first born babies. The subject loss resulted in a predominance of males. Nine (8 male and 1 female) were in the final sample. These were all healthy and apparently normal infants as indicated by their Apgar Scores after birth (Mean Apgar score at 1 mn was 8.0 sd = 1.41), range 5 - 9; at 5 mn was 9.44, sd = 0.68, range 8 - 10. Their mean age at the start of the study was 6.55 hrs, sd = 3.27 (range 2 - 13 hours). At the end of the observation they were from 50 to 108 hrs of age (Mean age - 73.41, sd = 19.41). The mean birth weight of the sample was 3.68 Kg, sd = 0.24, range 3.39 - 4.09 Kg. <u>Table 7.1.2 below shows the infants' sex, birth weight and Apgar scores.</u>

Table 7.1.2 <u>Infant's sex, birth weight and Apgar scores</u>

Ss	Sex	Birth Weight (kg.)	Apgar at: 1min	5 min
1	M	3.41	9	10
2	M	3.60	9	10
3	M	3.70	8	10
4	M	3.46	9	10
5	M	3.39	6	9
6	M	4.03	9	9
7	M	3.80	8	9
8	M	4.09	5	8
9	F	3.62	9	10
Mean		3.68	8.00	9.44
Sd		0.24	1.41	0.68

* The subjects were observed from the first hours of birth.

The birth method of 8 was normal (SVD) and one was sectioned (LUSCS). Explanations of these terms are provided in Experiment 2.1 (Method section). Five male infants were breast fed, 3 were bottle fed. The female infant was also bottle fed.

Experimental design

Measures

Selection of variables

The selection of variables was made on the basis of a review of previous studies of mother-infant interaction. Evidence suggests that contacts (visual, verbal, physical) occur in most caretaking behaviours especially feeding, changing, bathing and cleaning.

Face-to-face-interaction

Face-to-face-interaction was defined as a full face presentation of the mother and infant to each other, occurring at a distance judged to range from 8 to 30 centimetres. Face-to-face episodes were coded when initiated by one member and the other partner responded to it. The study was not concerned with who initiated the contact as the aim was to find out the duration of face-to-face interaction. Face-to-face interactions occurred in several contexts: a) when the mothers bent over the baby in caretaking, play, soothing and when they approached the infant just for checking.

For descriptive and analytic purposes eight basic categories of behaviours or contexts of contacts were distinguished. Further it was decided to develop some codes to identify the different behaviours and sub-behaviours on the recording formats.

1. Caretaking behaviours

These were cases in which the infant was transported to or from feeding, changing, being held for feeding or changing.

Tend was recorded whenever the mother was engaged in some form of caretaking such as wiping the nose, winding the infant after being fed.

Vocalizing: Vocalizing included speaking to the infant, making vocal noises and singing to the infant.

2. Affectionate behaviours: These involved

   a) Expressive (smiling, laughing, giggling and smiling and making sounds to the infant).

   b) Physical (kissing, cuddling and hugging the infant.

3. Visual behaviours: These were cases in which (1) the mother and infant fixated each other directly, (2) scanning, (3) peripheral viewing, (4) looking away, (5) closing eyes. Direct fixation was recorded when the mother's eyes and those of the infant's met fully in the same vertical plane of rotation, as Robson (1967) defined the en face position.

4. Play: This is when the infant is picked up for social interaction. It included:

a) stimulating the infant (attempts to attract and hold its attention with toys or touching nose or chin).

b) physical stimulation

i) minor physical: involving limited degrees of physical contact (e.g. tickling the infant or pretending to nibble it).

ii) physical: involving robust stimulation by hands on the chest, lips (e.g. rough and tumble).

5. Approaching the infant: The manner the mother approached the infant (gently, warmly, harshly) and the direction the mother approaches the infant (left, right, leaning over the infant's head, feet, back) was included to find out which of the poses of the mother's face the infant encounters more in face-to-face interaction.

6. Soothing: This was recorded when the infant was

distressed and needed comforting. The mother may have acted to soothe the infant:

a) physically ('winds' or picks up the infant).

b) verbally (using words or sounds).

7. Respondent: When the mother picked up the infant in response to a clear request to be held. The mother may have responded:

a) physically (picks up, cuddles, puts finger in infant's mouth.

b) verbally (using words or vocal noises).

8. Other All contacts that could not be categorized in any of the previous 7 categories.

These time sampling categories presented in Record Format 7.1.1 A. b. c. d. f. g. (See Appendix 7.1.1). were developed to reflect the main areas of contacts: visual (on both parts), auditory (the infant being exposed to the mother's voice), physical (the mother's caretaking behaviour). The duration of these contacts was recorded on Record Format 7.1.2

An additional descriptive categorization of the mother's and infant's states was included in this study:

1. Infant: sleeping, awake by itself (does not see the mother), awake with visitors, held by nurse.

2. Mother: sleeping, awake by herself, with visitors, absent from the ward, chatting with other mothers, reading.

The duration of each of these activities was recorded on a separate sheet (Record Format 7.1.3. Appendix 7.1.1). The times of the onset and offset of contact or activity were noted.

Reliability

All observations were conducted by the author. The reliability of these observations was examined by observing an additional group of 6 pairs of infants and mothers on the same wards. A naive observer was recruited and both observers recorded independently the frequency of the behaviours for 5 mins. The interobserver agreement ($r=0.85$, $p<0.05$, one-tailed) obtained using a series of Spearman correlations for the frequency of the different behaviours suggests that there was an acceptable level of interobserver reliability. The raw data are presented in Appendix 7.2.

Procedure

Each pair (mother-infant) was observed for the first few days they were in the hospital. All subjects were studied from their admission to the postnatal ward until they were discharged from the hospital. It was not possible to get access to the labour unit to commence recording at an earlier time.

The mothers were asked to behave as naturally as possible. They were free to move at will as if they were not observed. Only one observer was used to record the frequency of behaviours and duration of contact with the mother. First, the observer interacted with the mothers in an effort to make them feel comfortable about being observed, then retreated to a corner of the ward from where all pairs of subjects could be seen and recorded.

To find out the amount of time the neonate spends interacting with the mother long recording sessions were scheduled to take place during the day and evenings. Each day was divided into 3 main time samples (sessions). Two of the sessions were for 5 hours each, the third one was for 4 hours.

Each pair (mother-infant) participated in all of the sessions. The sessions labelled 1 and 2 were on the same day. The first one was in the morning and the second in the evening. Session 3 was in the afternoon of the next day. This sampling allowed the observer to rest between the two sessions and therefore reduce the effect of fatigue. The use of several observers would have been very beneficial, but the study was carried out as a single project, and it was not possible to find a volunteer to do the task.

Each session was divided into subsessions (1 hour each) with 5 minute breaks between subsessions. Each subsession was again divided into 12 periods of 5 minutes each. Since one of the aims of the present study was to determine the frequency of behaviours, the observer noted the number of times the behaviour occurred. If an infant fixated the mother once within 5 mins, the neonate would receive one tally mark for that behaviour. This method was used by Glen Heathers (1955), (see Irwin and Bushnell, 1988, p. 149) who employed time sampling to study dependency in preschool children.

The duration of each behaviour was recorded by noting down the times the behaviour started and ended within 5 mins. Olson (1929) who tested how long a child persisted with a nervous habit (duration) measured the length of time the child exhibited the behaviour within each time frame. Another 10 - 15 minutes were spent at the end of each session for noting down comments on the observation. The length of the observation varied across subject pairs from 55 to 102 hours (Mean 73.44, sd = 19.41). The frequency of the behaviours was recorded by tally marks using Recording Format 7.1.1 (see Appendix 7.1.1). On Record Format 7.1.3, the states of the mother and infant were noted. The times the infant and mother were interacting, for example, were noted, and this is how duration of mother-infant contacts was found (Record Format 7.1.2).

Questionnaire

In the course of observation, the mother was asked each morning whether she had fed or changed the infant during the night. In case of positive answers, the number of feeds or changes was recorded (see Appendix 7.1.2).

A photograph showing a mother and the observer

Results

This section is organized into two sections:

1) The total time the infant spent interacting with the mother.

2) Frequency of behaviours and subbehaviours category.

1. Total interaction time

To control for variations in the length of observation, scores were transformed into percentages. It should be pointed out that only data collected during the first three days of the infant's life was reported here. Figure 7.1.1 shows the mean percentage time the infant spent in face-to-face interaction with the mother, or with visitors and nurse and time spent sleeping and awake by themselves across the first three days. Only the data of the time spent in face-to-face interaction, with the mother were reported in tables as they are the most relevant for early face recognition which this thesis is about.

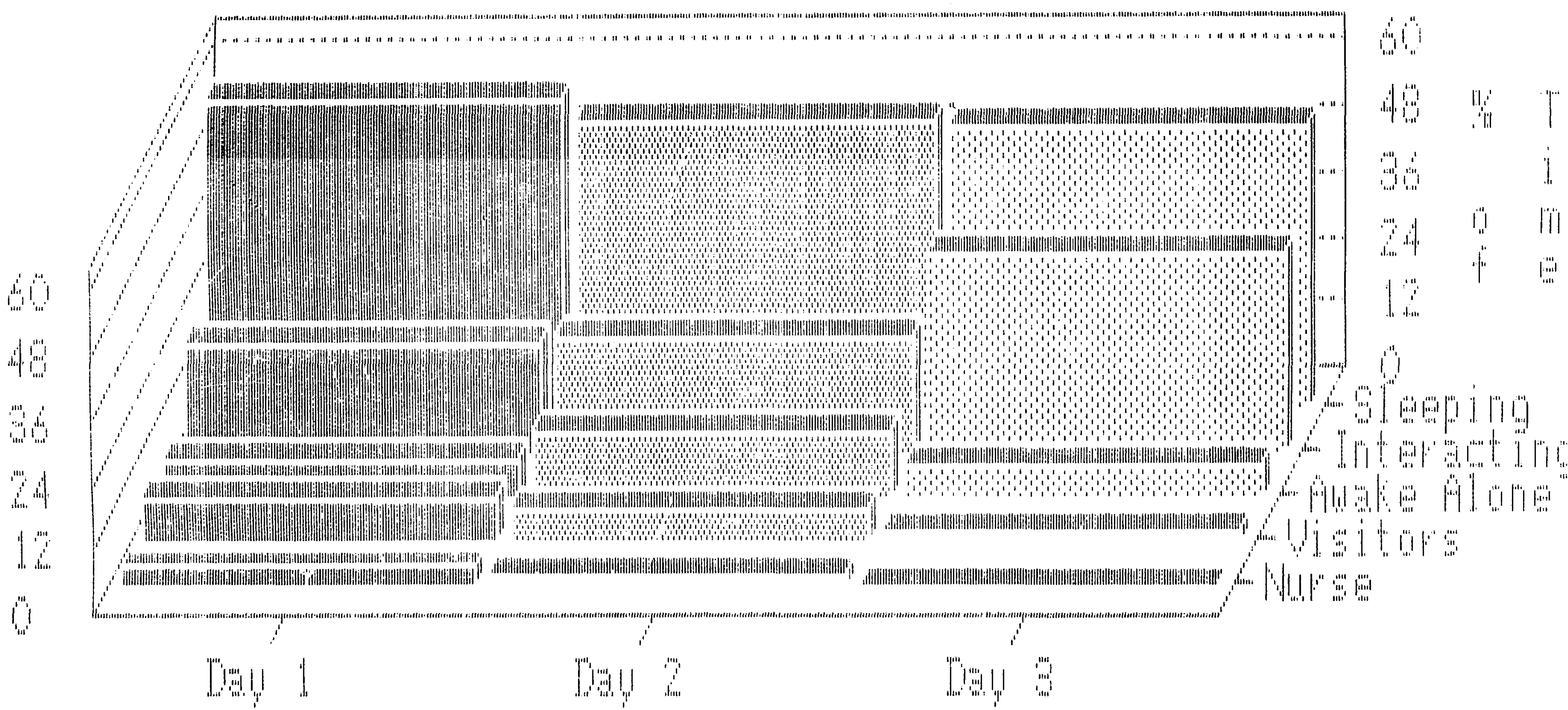


Figure 7.1.1 Percentage time the infants spent interacting with their mother, with nurse, visitors, awake by themselves or sleeping

1.1. <u>Total awake time spent in face-to-face interaction with the mother</u>

On average the infant spent 21.1% of time in face-to-face interaction with the mother on the first day of the infant's life. This amount increased slightly on the second day (22.5%). On the third day a clear increase was found (37.4%), (See <u>Table 7.1.3).</u> On Day 1, the infant spent most of the time sleeping. The amount of sleeping decreased slightly on Days 2 and 3.

Table 7.1.3.. Mean percentage time the infant spent interacting with the mother

Days	1		2		3	
Subject	Time	%	Time	%	Time	%
1	54	22.5	143	23.83	76	31.67
2	55	22.91	192	32	80	33.33
3	103	17.2	25	10.42	132	22.17
4	25	10.42	192	32	160	88.9
5	92	38.33	91	15.2	35	14.58
6	135	22.5	20	8.33	78	26
7	102	17	77	32.08	205	34.17
8	30	10	20	8.33	100	33.33
9	70	29.17	243	40.5	95	52.78
Mean		21.1		22.5		37.4
SD	8.4		11.5		20.7	
Range	10.38.3		8.33 - 40.5		26 - 88.9	

To determine whether the duration of contacts increased significantly across the first three days of the infant's life, a one-way Anova with one between subjects variable, Days (Day 1, Day 2, Day 3) was computed using the percentages time spent in face-to-face interaction with the mother. Table 7.1.4 shows the Anova summary table.

As a group, there were no significant differences in the amount of contact across days ($F(2, 24) = 3.10$, $p = 0.06$, NS). The p-value was, however, very close to reaching significance. Looking closely at the individual subjects (see Table 7.1.3), it can be seen that the amount of time the neonates spent interacting with their mother increased over the first 3 days. Only one subject (5) regresses. The amount of time decreased on Day 2 then increased again on Day 3 for subjects 3, 6 and 8. Overall, Day 3 clearly differs from Days 1 and 2 combined, indicating that with increasing age the neonate spends more time with the mother.

Table 7.1.4. Percentage time spent in face-to-face interaction with the mother

	Sum of Squares	Df	Mean Square	F. Ratio	P. Value
Days x	1472.6023	2	736.3012	3.1083	0.060053
Days x Subject Error	5685.1631	24	236.8818		

A Dunns multiple comparison was used to compare the means percentages time spent in face-to-face interaction with the mother across the first 3 days. The amount of contacts between mother-infant significantly increased between Day1 and Day3 ($t=3.79$, $df=8$, $p<0.05$). Also, this amount significantly increased between Day2 and Day3 ($t=3.49$, $df=8$, $p<0.05$). However, there was no significant difference in the amount of contacts between mother-infant between Day1 and day2 ($t=0.328$, $df=8$, ns). Thus, the amount of time spent in face-to face interaction between mother-infant is significantly different on Day3 compared to Day1 and day2.

2. Frequency of behaviour and sub behaviours

For the purpose of analysis, the number of times the behaviour occurred during the 3 days of observation were summed and converted into rates per hour of observation.

This equalized the contribution of each pair (mother - infant) to the group data and normalized the distribution of scores. The means reported in this section are rates per hour. The data revealed that mothers and their infant interacted through various caretaking and affectionate behaviours.

2.1 Frequency of behaviours

To determine the number of times or how frequent the neonate interacts with the mother during the first 3 days of life, the frequency of interaction was recorded as described in the procedure section. The mean rate per hour was then calculated.

The mean rate per hour of caretaking behaviours was 8.6. The highest contacts between mother-infant were in caretaking behaviours. The infant is not only fed or changed for that number of times, he is also exposed to the mother's face and voice about 8 times per hour during caretaking behaviours.

The visual behaviour contacts of both mothers (M = 5.3, and infants (M = 5.7) were about the same, that is 5 times per hour (Table 7.1.5). These results demonstrate that the mother and her newborn baby maintain visual contacts from the first hours after birth. They fixate and scan the faces of each other. This visual interaction may attract the neonate to the mother's face and lead to learning the features characterizing this face.

The mothers, as a group, were frequently responding to their infant's (M = 4.1). They responded about 4 times per hour. The infants were soothed (M = 3.9) about 3 times per hour when distressed. On average the mothers were often affectionate (M = 3.1) and therefore contacted their infants about 3 times per hour. Further, compared to caretaking behaviours play behaviours (M = 3.8) were less frequent. The mothers played with their infant about 3 times. Overall the mothers were engaged with their infant in social activity quite frequently. Mothers were also involved with their infants in "Other" behaviours (M = 0.4), but comparatively infrequently. The mean rate per hour of other behaviours was less then once per hour. Mothers, however, approached their infants more than three times per hour (M = 3.1).

From Figure 7.1.2, it can be seen that all behaviours but one occurred at least three times per hour, only "other" behaviours were less frequent. The neonate experiences the mother's face 8 times during caretaking behaviours, 4 times when the mother responded to the infant, about 3 times during affectionate behaviours, playing with the neonate, and when approached the infant. The mother and infant interacted visually about 5 times, during which the neonate clearly saw the mother's face. Indeed the neonate is frequently exposed to the mother's face from the first hours after birth.

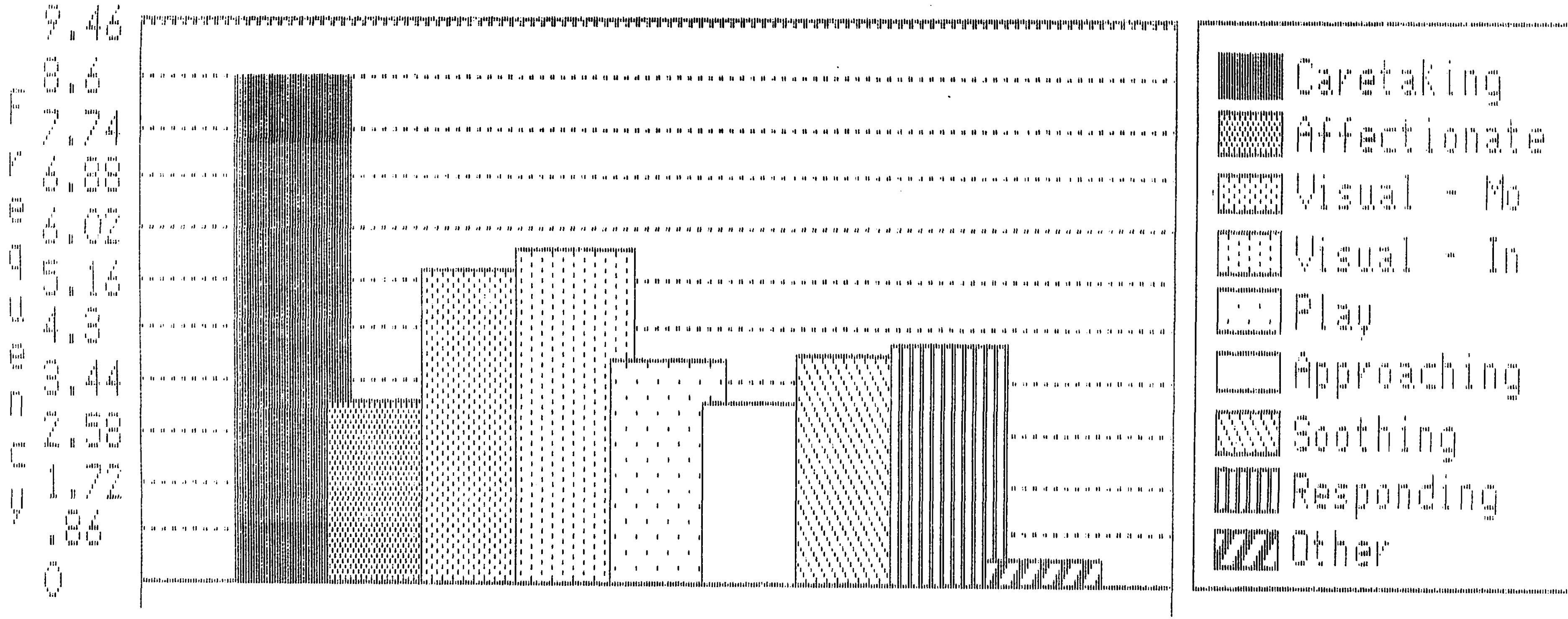


Figure 7.1.2 Distribution of frequercy of behaviour.

Table 7.1.5. Mean rate of contacts per hour for each behaviour category for all subjects (N = 9)

			Mean
1.	Caretaking behaviour	Feeding	1.1
		Changing	0.7
		Tend	1.8
		Verbal	4.7
		Total	8.6
2.	Affectionate	Expressive	2.0
		Physical	1.1
		Total	3.1
3.	Visual Behaviour	Mother	5.3
		Infant	5.7
		Total	
4.	Play	Stimulating	0.8
		Physical	2.9
		Total	3.8
5.	Approaching the infant	Manner	1.3
		Direction	1.7
		Total	3.1
6.	Soothing	Physical	1.1
		Verbal	2.8
		Total	3.9
7.	Respondent	Physical	1.5
		Verbal	2.5
		Total	4.1
8.	Other		0.4

2.2 Frequency of sub behaviours

Since one of the secondary aims of this study was to find out which behaviours mother and infant are mostly engaged in when they are in contact with each other, it was felt advisable to report the mean rate of sub-behaviours per hour for the sample as a whole (Table 7.1.6).

2.2.1 Caretaking behaviours

The neonate was fed about once (M = 1.1) per hour and changed less than once per hour (M = 0.7). The mothers were more frequently engaged in feeding and changing than taking the infant to or from feeding or changing. The mothers, were involved in winding the infant (M = 1.1) about once per hour. Cleaning and drying the face (M

= 0.7) occurred less than once per hour. The neonate thus experienced the mother's face at least once per hour during which the baby was fed and changed.

During feeding and changing processes, the mothers vocalized to their infant (M = 4.7) about 4 times per hour. Overall, they spoke (M = 2.5) about twice and made vocal noises (M = 1.8) about once or sang (M = 0.3) less than once per hour. Caretaking behaviours were dominated by the mothers' vocalizations.

Table 7.1.6. Mean frequencies and standard deviation of events per hour for 8 behaviour categories

Behaviour Categories			Mean	S.D.
Caretaking		F1	0.3	0.2
	Feeding	F2	0.5	0.4
		F3	0.3	0.2
	Changing	CH1	0.2	0.1
		CH2	0.3	0.2
		CH3	0.2	0.04
	Tend	WIP	0.7	0.4
		WIND	1.1	0.7
	Verbal	SPK	2.5	1.1
		MVN	1.8	0.8
		SING	0.3	0.3
Affectionate	Expressive	SMIL	0.6	0.4
		LAUG	0.3	0.3
		GIG	0.4	0.5
		SMI/SO	0.8	0.9
	Physical	KISS	0.5	0.3
		HUG	0.2	0.3
		CUD	0.4	0.4
Visual behaviours	Mother	DF	1.3	0.6
		SN	0.9	0.6
		PV	1.0	0.7
		LOW	1.2	1.2
		CEY	0.9	1.2
	Infant	DF	1.3	1.1
		SN	1.2	0.9
		PV	1.0	0.8
		LOW	1.0	1.0
		CEY	1.2	0.9
Play	Stimulating	ST	0.4	0.4
		AHA	0.5	0.6
	Physical	TIC	0.5	0.5
		NIB	0.6	0.4
		ROU	0.7	0.6
		TUM	1.1	2.0
Approaching the infant	Manner	GEN	0.5	0.4
		WAR	0.6	0.5
		HAR	0.2	0.2
	Direction	RIG	0.4	0.1
		LEF	0.2	0.2
		FEE	0.6	0.5
		HEA	0.2	0.3
		SIDE	0.4	0.4
Soothing	Physical	WIN	0.6	0.4
		PIC	0.5	0.4
	Verbal	SO/M	0.9	0.8
		WOR	0.8	0.6
		SOU	1.1	0.8
Respondent	Physical	PIC	0.3	0.1
		CUD	0.4	0.5
		FING	0.7	0.6
	Verbal	WOR	1.1	0.9
		VON	1.4	1.2
Other			0.4	0.5

2.2.2 Affectionate behaviours

Overall expressive behaviours occurred about twice per hour (M = 2.1). They were more frequent than physical behaviours which were once per hour (M = 1.1). The rates of the mother's smiling accompanied by sounds (M = 0.8) and smiling alone (M = 0.6) occurred less than once per hour. Also mother's giggling (M = 0.4, laughing (M = 0.3), kissing (M = 0.5), cuddling (M = 0.4) and hugging (M = 0.2) occurred less than once per hour.

2.2.3 Visual behaviours

On average mothers (M = 5.7) and their newborn babies 5.7) were frequently engaged in visual contact. They visually interacted about 5 times per hour. As early as the first few days, infants saw the mother's face at least 3 times per hour. Similarly mothers looked at their infant's face about as frequently. They fixated their infant's face (M = 1.3), scanned (M = 0.9), and showed peripheral viewing (M = 1.0) about once per hour. Infants fixated (M = 1.3) and scanned (M = 1.2) their mother's face for the same number of times per hour. They also demonstrated peripheral viewing (M = 1.0) once per hour. The mothers looked away (M = 1.2) while their infant was still fixating their face and, they closed their eyes (M = 0.9) about once per hour. Similarly, the infants closed their eyes (M = 1.2) and they looked away (M = 1.0) while their mothers were still fixating their faces about once per hour.

2.2.4 Play

The mothers attempted to stimulate the infant (M = 0.9) about once per hour. Physical stimulation was more frequent (M = 2.9), about 3 times per hour. Tumble play (M = 1.2) in which the mother played with the baby by stimulating the infant with toys, or by lifting the infant then returning him to her lap, occurred once per hour. Rough behaviour (M = 0.7), such as the mother putting her hand on the infant's chest while moving it, tickling (M = 0 .5), and pretending to nibble the infant (M = 0.6), occurred less than once per hour.

2.2.5 Approaching the infant

Overall, mothers were warm (M = 0.6) or gentle (M = 0.5) less than once per hour when approaching their infant. As anticipated mothers rarely demonstrated harsh behaviour (M = 0.2).

Since the aim of this study was to find out the total awake time spent in face-to-face interaction with the mother, it was decided to note the side the infant sees the mother from, and its frequency of occurrence. During caretaking, the mother seemed to approach the infant leaning over his feet when the baby was lying flat on his back (M = 0.6) less than once per hour. The rates of approaching the infant leaning over the infant's side (M = 0.4) and the right hand side were the same that is less than once per hour. The lowest frequencies were those of leaning over the left hand side of the infant (M = 0.2) or his head (M = 0.2). The rate of approaching the neonate learning over his feet when the baby was lying flat on his back was the highest indicating that in most contacts the neonate experiences the full face of the mother. Indeed during caretaking behaviour, especially when changing the baby faced themother's face.

2.2.6 <u>Soothing</u>

When the infant was distressed, mothers as a group used sounds (M = 1.1) about once per hour, and words (M = 0.8) to comfort their infant less than once per hour. Soothing with movements and walking (M = 0.9) occurred on average almost once per hour. Winding (M = 0.6) the baby while in a bassinette or picking it up (M = 0.5) were less frequent, about less than once per hour. During soothing behaviour the mother used more voice than physical contact. The neonate thus was exposed to the mother's face, voice and body heat about once per hour when being soothed.

2.2.7 <u>Respondent</u>

Using vocal noises or sounds (M = 1.4) and words (M = 1.1) in response to the infant's clear needs occurred about once. Putting a finger in the infant's mouth (M = 0.7) was less than once per hour. The mean rates of occurrence of cuddling (M = 0.4) and picking the infant up (M = 0.3) were about the same that is less than once per hour.

2.2.8 Other

All holds and behaviours that could not be categorized in any of the previous 7 categories of behaviours occurred infrequently (M = 0.41) thus confirming that the main categories were efficiently established in the first instance.

3 Frequency of feeding and changing at night

At night, most of the mother - infant contacts seemed to cluster around caretaking activities. On average infants were fed at least once during the first night of their lives. Changing the infant appeared to increase from night 1 to night 3 so that most babies were changed on night 3. This would be expected from the neonate's metabolism process beginning to function normally. (see ~~Table 7.1.4~~ and Figure 7.1.3).

Breast fed babies were more frequently fed than bottle fed infants. This behaviour of feeding during the night is different from that observed during the day time observation periods, but since it was reported by mothers rather than directly observed one has to be cautious when commenting on it.

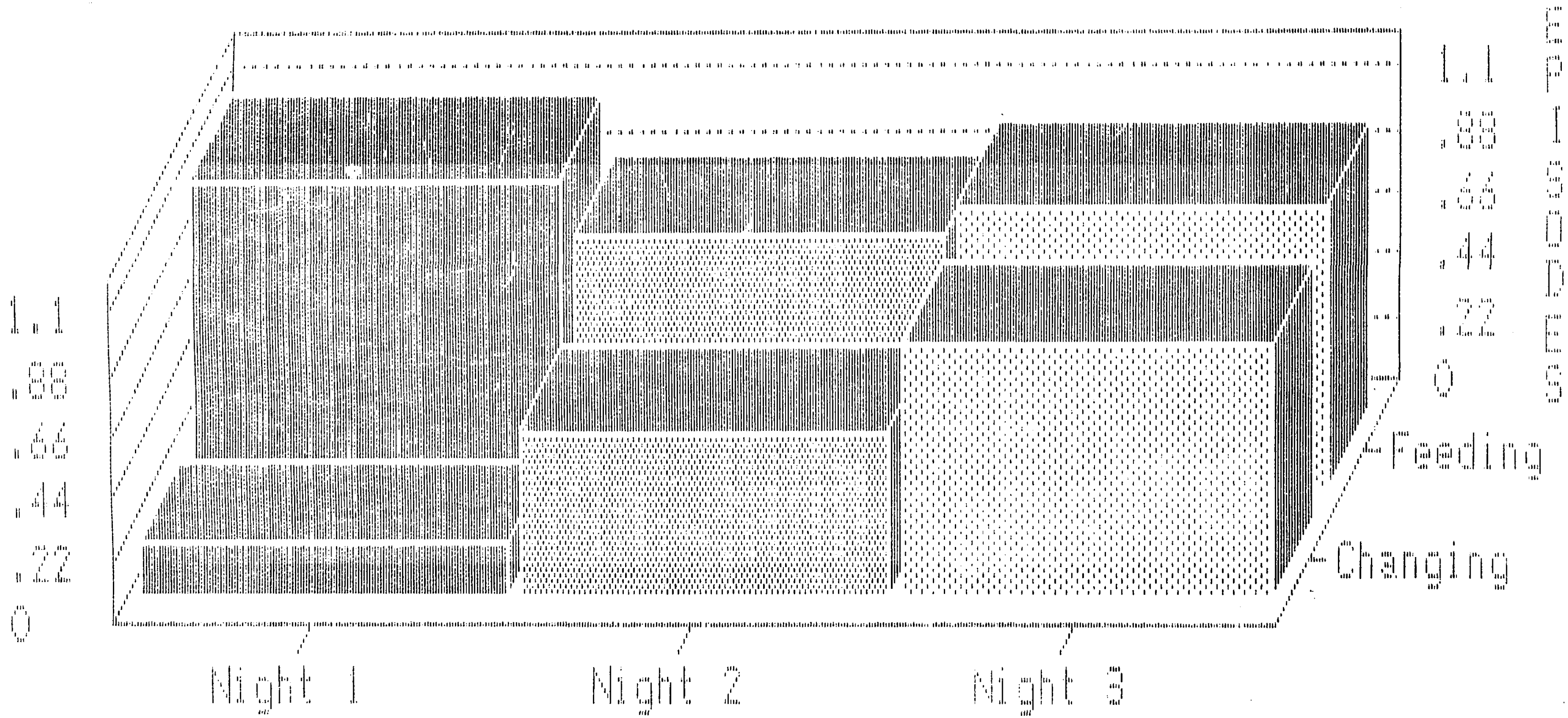


Figure 7.1.3 Frequency of feeding and changing at night.

Table 7.1.7

Mean number of feeding and changing at night

Method of Feeding	Night 1		Night 2		Night 3	
	F	CH	F	CH	F	CH
1 Bottle	0	0	1	3	1	1
2 Breast	2	1	1	1	3	2
3 Breast	2	0	2	0	1	1
4 Botle	0	0	2	1	0	0
5 Bottle	0	0	0	0	0	0
6 Breast	1	0	2	0	0	0
7 Breast	2	1	0	0	1	1
8 Breast	1	0	0	0	2	2
9 Bottle	2	0	0	0	1	1
Mean	1.1	0.2	0.9	0.6	1.0	0.9
SD	0.9	0.4	0.9	0.9	0.9	0.7

Discussion

The findings from this preliminary study provide interesting information about the amount of time the neonate spends in face-to-face interaction with the mother across the first three days after birth. The data also point to the behaviours that infants and mothers are most frequently engaged in when they are in contact with each other.

From the present results, it is clear that the infant does not spend all 24 hours in face-to-face interaction with the mother. On their first day, neonates spent most of their time sleeping (see Figure 7.1.1), with few contacts with their mother. Though the neonates were retained on the ward at all times in bassinets (located at the foot of their mother's bed) while under the care of their mothers, in the first 3 days they spent 21%, 22.5% and 37.4% of their time in face-to-face interaction with the mother.

The percentage of time spent in face-to-face interaction with the mother increased over the first three days. The significant increase was between Day1 and Day3, and between Day2 and Day3. However, the amount of time spent in face-to face interaction with the mother did not significantly increase between day1 and Day3. Thus, Day3 significantly differs from Days 1 and 2 combined. This was probably due to the greater availability of the mother after the second day.

The significant increase in face-to-face interaction between Day1 and Day3, and between Day2 and Day3 is not consistent with the findings of Experiment 2.1, 4.1, 4.2 and 4.3 that preference for the mother does not increase with the increasing age of the infant.

Since the present study did not test neonates after being observed, it is still not known if there is a relationship between the total contact hours involved between the mother and her newborn baby and the extent of preference for the mother. As all relevant Experiments in this thesis demonstrate the neonates' ability to recognize the en face pose of the mother indicated a non-significant increase of preference for the mother with increasing age, the results of the present study could be related to Experiment 2.1 for example.

Both younger and older infants occasionally showed greater preference for the mother and at other times demonstrated less preference, whereas the amount of face-to-face interaction the neonates (except one) had with their mother in the present study, increased over time. The time the infants spent interacting with the mother on Day 3 clearly differs from Day 2 and Day 1. If age were an important factor in early face recognition during the first three days of life, preference for the mother might be expected to increase over the first 3 days as did the amount of face-to-face interaction with the mother. The presence of preference for the mother in babies less than 12 hours indicates that the en face pose of the mother is learnt rapidly and does not require much experience to be stored and recognized.

With repeated exposure to the mother's face, the newborn infant comes to learn the specific features that distinguish the mother's face, but as Experiment 2.1 demonstrated, the amount of exposure necessary for the neonate to learn the mother's face is surely less than 12 hours. The results of the present study thus suggest that neonates are very rapid in learning the mother's full face. A certain amount of face-to-face interaction is enough for learning the mother's face. Perhaps the neonate remembers it from the first contact. A study designed to videotape the first contact between the mother and her newborn baby and then test early face recognition is required.

Looking closely at the individual subjects it is impossible to draw conclusions as to whether the amount of face-to-face contact with the mother was influenced by the sex or birth order of the infant since these two variables were not represented equally in the final sample. The greater preference for the mother demonstrated by male neonates in Experiment 2.1 can be attributed neither to the amount of exposure to the mother face nor to chance at this stage. A study designed to examine the effect of sex on early face recognition is needed.

When they are in contact with each other, mothers and infants are frequently engaged in caretaking behaviours. The mother interacted with her newborn baby about 8 times per hour, mostly vocally during feeding and changing. Thus, the neonate sees the mother at least 8 times per hour which is quite enough for learning that face, especially when the visual interaction is accompanied by the voice of the mother. Feeding was scheduled once per 4 hours but mothers fed their babies once per 2 hours. Breast fed babies (n = 5) were more frequently fed than bottle fed (n = 4). Though, experiments reported in earlier chapters showed no difference between breast and bottle fed infants in the amount of preference for the mother, the individual scores of this study indicate that breast fed babies maintained longer contacts with their mothers during the feeding process. These findings are consistent with those of Richards & Bernal (1972) that breast fed infants feed for longer periods. Accordingly early face recognition must be attributed to the amount of information the neonate can detect in a certain period of time rather than to the length of exposure to the mother face. If the length of contact is an important factor in early face recognition, breast feed babies would have demonstrated greater preference for the mother in earlier experiments of this thesis as they are more exposed to the mother face. The ability to recognize the mother's face also suggests the presence of certain mental capacities. During caretaking behaviours, the newborn baby is exposed to the different orientations of the mother's face. The full face pose is more encountered than the 3/4 profile and profile poses, and when experienced during caretaking behaviours the latter poses are not maintained by the mother for longer times and at the same angle, and even if such poses are experienced for longer time the newborn infant has still not the capacity to detect the invariance across variance.

Drying and winding the infant was the most frequent caretaking behaviour. This physical contact occurred more than once per hour. This is due to the infants' state in the first days of life. They usually vomit and regurgitate food after being fed. Though winding the infant was frequent, the mother and infant did not usually establish face to face interaction. The infant was sat on the mother's lap, but not facing her.

During these caretaking activities, mothers vocalized more frequently than in soothing or respondent behaviours. These findings confirm those reported by Osofsky (1976) which indicated that the area of greatest specificity in maternal and infant behaviour during feeding interaction was in the auditory domain. During physical contacts, the infant is exposed more to the voice of the mother. The infant therefore might associate the mother's voice with the face through the reinforcement process, that is hearing the mother's voice while being fed.

Secondly, mothers and infants contacted each other frequently when mothers responded to their infants' clear needs. They particularly they used vocal noises and words more frequently than they responded by picking the infant up, cuddling or inserting their finger in the infant's mouth.

Thirdly, mother-infant contact occurred when the mother was involved in soothing. Again the mothers used sounds, sounds and movements or words more than they picked up or winded their distressed baby. Some mothers explained that they did not want their babies to get used to being held because they were going back to work in a few months.

Fourthly, mothers were often involved in affectionate behaviours, specifically expressive ones. The highest frequency was that of smiling accompanied by sounds. Laughing and giggling were less frequent. Similarly, kissing, hugging and cuddling occurred less often. Overall expressive behaviours occurred twice per hour, whereas physical behaviours occurred just once. The data indicate that most of these affectionate behaviours occurred when mothers were involved in caretaking activities. This observation is in line with Park, Grossmann and Tinsley (1981) findings. Though breast feeding mothers show more affectionate behaviours and vocalizations during feeding, Experiment 4.2 which controlled method of feeding did not indicate differences in early face recognition between breast fed and bottle fed neonates. The extent of preference does not appear to be related to the amount of vocalization the neonate was exposed to.

During play activity, mothers used more physical contact than stimulation or hold their infant's attention. In physical contact, mothers also talked, smiled and looked at their infants. The frequency of maternal vocalizations was not included in play as this activity was not anticipated in the neonatal period. Indeed not all mothers did engage in play with their infants, but the one whose mother played with him was exposed to the mother's voice and physically contacted the mother about 3 times which could have led the neonate to learn the mother's face.

During the following behaviours: responding to the neonate, soothing, playing, and during affectionate behaviours, the mother established face-to-face interaction with the neonate. The mother spoke to her baby, and exposed her infant to her body heat and odours. In this complex interaction all senses are involved and therefore contribute in visually learning the mother's face.

Mothers and infants seemed to have been frequently involved in visual contact, though it was difficult to record this behaviour, especially because there was just one observer, and detailed analysis of visual behaviour must really utilise video recording facilities. Thus a further study would require the use of such accurate equipment together with several different observers and coders. This would help to relate the frequency and type of visual contact to early face recognition.

The finding that neonates frequently interact visually with their mothers is in accord with Brown et al's (1975) results that, during feeding periods, 3 day-old infants interacted visually with their mothers for 6 minutes (21%) and that they had their eyes open for a total of 13 minutes (43%) in 30 mins observation. Visual contact increased during soothing behaviours.

The high frequency of visual fixation found in the present study suggests that from the first hours of birth, infants are visually attracted to the mother and control visual behaviour, directing it towards the mother. This finding supports the results of this thesis that neonates aged 12 hours are able to visually recognize the mother and contradicts the suggestion that at birth the newborn baby cannot see. The neonate is not only able to fixate but he is capable of frequently maintaining a visual interaction. During the visual contact there is no doubt that at least some visual processing is taking place which involves both some basic perceptual capacities and visual memory.

The data from this study indicates that in the first three days of life, most observable mother-infant contact stimulates all sensory domains. On the basis of the present data, the early experience with the mother's face is quite enough for learning the mother's face. The neonate feels the mother physically while seeing her face and hearing her voice. Exposure to her body heat, her smell and her heart beat also occurs while his primary motivations (hunger and thirst) are being satisfied.

Thus all modalities are involved in early contacts, and this is important, since evidence suggests that infants can encode information cross-modally (Butterworth, 1987).

As far as the selected behaviours are concerned they provided information about the different contacts the mothers and infants maintain in the first three days of life and their occurrences. There is however some doubt about the representativeness of the time periods during which sampling took place. It would be ideal to have carried out sampling across a 24 hour period, but this was discouraged by the hospital and practically very difficult for a single observer to accomplish. However, the time sampling that was carried out did indicate a significant amount of maternal face exposure and this was the fundamental reason for conducting the study.

Conclusion

In this chapter evidence has been presented demonstrating that newborns spent a third of their awake time in face-to-face interaction with the mother from, the first few hours following the infant's birth, and that this amount significantly increase between Days1 and 3, and between Days 2 and 3, but not between Days1 and 2. This finding is not consistent with the results of the experiments of the present research indicating a non-significant correlation between age and extent of preference for the mother's face. Age does not appear to be an important factor in early face recognition.

During the first three days of life, mothers and their infant are frequently engaged in caretaking activities and in comforting, responding and soothing the infant. Most of the behaviours are dominated by the mother's vocalizations. Also mothers and infants maintain frequent visual contacts. The neonate is exposed to the different orientations of the mother's face but no pose is maintained at the same angle for longer time. The full face is more often experienced.

Though this study is not methodologically ideal regarding procedural aspects, the present data clearly indicate that, from the time of birth, infants and mothers are not in continuous contact but that sufficient contact must be being made for neonates to rapidly learn the en face pose of the mothers face. The amount of face-to-face interaction with the mother the newborn spent on the first day is small, but experiments in this thesis have demonstrated recognition of the en face pose of the mother in neonates aged only a few hours. The mother's full face does not appear to require extended exposure to be learnt as does the 3/4 profile pose. The en face pose is perhaps learnt during the first few contacts as both the mother and her newborn baby spent most of their time on the first day sleeping. The association between the mother's face and voice could be reinforced from birth with food and comfort as a reward. In addition it is clear that all modalities, particularly visual and auditory, are involved in early face-to-face interaction and this may be an important contributor to early face recognition.

Chapter 8

GENERAL DISCUSSION

Specific results of individual experiments were discussed in some detail as the studies were reported. In this chapter a summary of the main results is presented and the discussion is devoted to a more general consideration of the findings of the investigation as a whole.

The principal aim of this research was to explore when and how newborn infants process information about faces. To answer this question, the ability of neonates to discriminate and recognize the mother's face was examined.

1.1. Evidence for early face recognition and the processing of visual information in the neonatal period

In Chapter 1, limited evidence for an innate preference for the human face was presented. By 4 months and even 2 months (Kleiner and Banks, 1987) ~~neonates~~ INFANTS respond to the whole configuration of a face and features. By 2 months they fixate the internal features of a face particularly the eyes.

Recent evidence indicated that face discrimination between at least mother and female stranger is possible at 1 month of age (Maurer and Salapatek, 1976; Bushnell, 1982), or at 1-week of age (Carpenter et al., 1970; Carpenter, 1973) and even at 2 days of age (Field et al., 1984).

This evidence indicating face discrimination at different ages comes from research which suffer from considerable shortcomings concerning the methodology and the stimuli used. The earlier studies did not present real faces. Maurer and Salapatek (1976) used mirror presentation of real faces, Bushnell (1982) utilised colour slides of real faces. Carpenter (1973) used only one stranger's face for every subject. Where real faces were presented to newborn babies (Field et al., 1984), olfactory information was not controlled. This information is an important variable especially because MacFarlane (1975) demonstrated that at 5 days of age neonates are sensitive at least to breast milk odours.

The results of the initial experiment (2.1) indicated that neonates aged between 12 and 108 hours (Mean age 51.29 hrs) recognized their mother's live face even when voice cues were unavailable. These findings confirmed Field et al.'s (1984) result.

One possible explanation is that neonates may learn some visual aspects of their mother's face in the first few hours after birth. However, since this experiment (2.1) did not control olfactory information, the possibility remained that neonates could have responded to their mother's odours rather than demonstrating a visual processing capability.

Experiments 4.1 and 4.2 which investigated the role of olfactory information in early face recognition indicated that neonates were able to identify their mother's face both when the brightness of the faces of the mother and that of a non-parturient, non-lactating female stranger varied non-systematically across subjects, and when the mother and that of a parturient, lactating female stranger were matched as closely as possible for hair colour, hair length and facial brightness. The possibility that neonates are so sensitive to olfactory cues that they could still detect their mother's odours, the olfactory mask being ineffective was tested. The results of Experiment 4.3 in which neonates were prevented from seeing their mother's face provided strong support for very early face recognition based on visual cues. The mother's face was still preferred to the stranger's even when a control over the observer's bias was implemented.

The results that neonates only a few days of age could recognize their mother's face even when olfactory and auditory information was unavailable, and when the mother and stranger's faces were matched for facial brightness demonstrates that newborn babies are able to make finer discriminations than previously thought. Further, these data EXTEND ~~extent~~ and validate the findings of Noirot (1977) and Field et al. (1984). Also, they give support to research which combined representational and live faces (e.g. Carpenter et al., 1970 and Carpenter, 1974) or involved voice cues (Carpenter, 1973). The present research thus concludes that face discrimination - at least between mother and a female stranger, and when tested under the present experimental procedures - is clearly possible in the neonatal period.

The most interesting finding is the demonstration that newborn infants are capable of processing visual information in the first few hours after birth. This thesis, however, does not argue that neonates are not able to perceive olfactory information. Evidence has indicated that human neonates are able to perceive olfactory stimuli within the first days after birth (e.g. Engen, Lipsitt and Kaye, 1963; Engen & Lipsitt, 1965; Rovee, 1969; Self et al., 1972 and Sarnat, 1978) when tested at 1-2 cm. Reports have also demonstrated that neonates at ages ranging from 4 days to 6 weeks orient preferentially to the breast odour of their mothers (Macfarlene, 1975; Russell, 1976; Schaal et al., 1980). The odours of the axillary region of the mother were also preferred by 2 week-old-breast feeding infants to those of a strange mother in Cernoch & Porter's (1985) study. In this group of studies, the odours were presented at much closer distances than in the present experiments.

One question that arises at this stage is what processes support this amazingly early ability to detect appropriate visual information from the face; discriminate amongst different faces; and recognize a specific face? The first important process must be one which directs the infant's attention to the face so that information for the face can be picked up. However, there must be some doubt about whether or not there is a specific innate programming of face configuration and thus an inbuilt salience of the face per se. Goren et al.'s (1975) and Dziurawiecz & Ellis's (1987) results tend to support the inbuilt template thesis, although there are alternative possible explanations of their results which would not require such specific inbuilt preprogramming. A more recent study by Kleiner and Banks (1987) suggests that preference for faceness as far as the two dimensional patterns are concerned does not develop until the second month of life (see Chapter 1 for details about this study). First, Kleiner (1987) (who tested whether the linear systems model can predict pattern preferences for meaningful stimuli using schematic faces and abstract patterns) reported that neonates' preferences were governed by different stimulus properties rather than by the familiarity or social significance of stimuli. Neonates' preferences, thus, appear to be based on stimulus energy, as indexed by the amplitude spectrum (which represents the amplitudes (contrasts) and orientations of the sinewave components), whereas 2 months-olds' preferences seem to be based on stimulus structure as indexed by the phase spectrum (which represents the phases and orientations of the components).

This finding contradicts the hypothesis suggesting a prepardness to attend to faces. If such assumption were true, neonates would have preferred the schematic face not the pattern that looks like a lattice in Kleiner's study. Kleiner used Piotrowski and Campbell's (1982) technique to create hybrid images for a preference experiment with newborns. In this study, the amplitude spectrum of a military tank with the phase spectrum of a face were combined. To adults, the resulting pattern looked like a face and not a tank. They concluded that the phase spectrum of a stimulus was the primary determinant of its perceived identity. Thus patterns whose structure or configuration are facelike should be highly preferred. Accordingly, Kleiner's (1987) findings showed rather clearly that neonates' preferences were predicted from amplitude spectrum and not from the phase spectrum, thus providing direct evidence against the assumption of the existence of a specific programming of face configuration which Goren et al.'s (1975) and Dziurawiecz & Ellis ' (1987) results support.

However, these alternatives - concentration of contour density within an outline and spatial frequency component analysis can also be held to support a degree of preprogramming of visual processing such that faces will more typically than most other experienced stimuli attract the infant's attention. So all of the suggested explanations of Goren et al.'s and Dziurawiecz and Ellis's results can be held to indicate an especially preparedness to attend to faces. Certainly, the infant is strongly attracted to faces and it is clear from the observational study that the mother herself is very concerned with establishing face-to-face contact. This is quite extensive over the first few days and the hours of active experience must provide sufficient information to estabish early discrimination and recognition.

The linear systems model argues that facelike patterns are fixated preferentially because they contain large (low spatial frequency), high-contrast features that are arranged symmetrically (Banks & Ginsburg, 1985; Fantz, Fagan & Miranda, 1975; Haith, 1978; Karmel & Maisel, 1975). This model which has successfully predicted preferences among a wide range of abstract, non representational patterns from birth to 3 months of age and neonates' preferences when representational patterns were used (Kleiner, 1987) cannot account for the findings of the present research which utilised three-dimensional live faces.

The pairing of two faces of the mother and a female stranger with similar hair colour, hair length and facial complexion challenges the linear systems model explanatory powers. This model predicts no preference for one member over the other because they contain the same identical spectra (which represent the amplitude (contrasts) and orientations of the sinewave components).

The linear systems model thus cannot account for the results of this research which used two comparable three-dimensional live faces, one of which is the mother's. However, the neonates' sensitivity to low spatial frequency and high-contrast features could have led them to learn and remember the mother's face before the testing occurred; and the preference for the mother demonstrated during the testing could have been a long-term memory effect. This learning would not include the face meaning as the linear systems model would not predict the stimulus meaning. It predicts a preference for facelike stimuli over other patterns except to the extent that the filtered face provides spatial frequency and contrast information that fits the infants' visual "window" -the CSF- better than does the pattern with which it is paired.

If newborn babies are responding to the face-like characteristics of the schematics ~~and~~ THEN this ability cannot be attributed to early learning but rather to an innate predispositional mechanism. Then neonates' attention may be directed to face-like stimuli by this innate system. Once attention is directed towards a face, a secondary learning mechanism is then engaged to process a particular face. This latter system governs the recognition of individuals, including the mother's face. Morton (1987) argues that early face recognition is not possible as this secondary system develops slowly in the first months of life. The claim that the visual cortex and superior colliculus subserve different functions is consistent with the anatomical and physiological findings of studies on animals (Bronson, 1980). A recent support for a this view comes from Johnson and Horn's (1986) study on chicks. Researchers have proposed two neural systems underlying filial preference behaviour in the domestic chick. First, a predisposition which serves to orient the chick towards objects resembling adult fowl. Second, a learning system which is engaged by specific objects, including the bird's mother.

Following destruction of the intermediate and medial part of the hyperstriatum ventrale (IMHV), a region of the chick forebrain underlying the learning system but not the predispositions, chicks were not able to learn to recognize an individual adult fowl. Their predisposition has not been impaired. This suggests that the integrity of the intermediate and medial part of the hyperstriatum ventrale (IMHV) is necessary for the functioning of a learning system in chicks which is involved in the recognition of individual members of a species during imprinting. Horn's results are consistent with the hypothesis that IMHV is involved in learning to recognize individual birds, and other objects.

The model of face processing and recognition proposed by Morton is a two-process model that makes use of the two-visual system dichotomy suggested by Bronson (1974, 1982), Trevarthen (1968, 1970), Haith (1980) and others. This model argues that the secondary, subcortical visual system, which is concerned with spatial location, has the essential control over activity until the second month of life, and that the primary system mediating the perception of patterns, does not function at birth (Bronson, 1974, 1982 and du Preez, 1974).

It follows, if the neocortical networks are immature at birth and the newborn's behavioural repertoire is mediated in large degree by subcortical networks one could not expect the neonate to discriminate between two complex stimuli such as the real faces of the mother and that of a female stranger, let alone to recognize one. The sub-cortical system is designed only to locate stimuli.

Thus, the findings of the present research do not correspond to the predictions of the two-visual system model. The two-visual system model could perhaps account for the information picked up from schematic face processing but it cannot explain the processing of information from real faces, especially the mother's face. Since there is no doubt about the neonate's capacity to recognize the mother's face and process visual information, the propositions of the two visual system model cannot be accepted. Until the distinction between cortically and sub-cortically mediated processes is revised and the sub-cortical system's abilities are re-evaluated, or another model based on evidence from studies on human rather than animals is developed we must accept the suggestion that neonates are capable of learning to recognize the mother's face and remember at least some visual aspects.

Support for this suggestion comes from Experiment 4.4 which also indicated that mothers as a group were not attempting to capture their infant's attention during testing, but neonates could recognize the mother's face displaying static expressions.

The suggestion that the cortical and subcortical projections represent distinct parallel systems is perhaps false as there seem to be interactions between the two projections as the findings of Banks and Salapatek (1980) indicated. Bronson proposed the existence of such interaction only at higher levels, but the characteristics of deep cells in the monkey's superior colliculus rely on cortical influence. Other evidence indicates that the development of superior colliculus in cats does not frequently precede the development of the visual cortex. Research on kittens demonstrated that cortical cells showed adultlike response characteristics before any collicular cells are sensitive to visual stimulation (Stein, et al., 1973b, Blackemore & Van Sluyters, 1975).

Evidence from animals studies seems unlikely to account for humans' early visual development. Differences exist between animals and humans. Maurer and Lewis's model based on kitten's data which showed distinction between X and Y cells (Daniels et al., 1978) should be revised. Recent evidence indicated that the animal segregation of monkey X and Y cells is not as distinct as once thought (Kaplan & Shapley, 1982), though it is distinct in cats. In any case even if X and Y cells are dichotomous in kittens and animals an extrapolation from animals to humans must be treated cautiously. The findings of the present research supporting Field' et al., (1984) results presents a direct evidence against the two visual system model indicating the neonate's inability to visually discriminate and visually remember real faces. The present results raise doubts about the existence of a distinction between the two systems (primary and secondary) in humans. A revaluation of the two visual systems model is required.

The features that neonates are basing their discrimination on are still not determined. Perhaps neonates' attention is retained by the angles of the triangle which the eyes and the mouth constitute. If one looks carefully at Figure 2.1.1 (Chapter 2) it is clear that each face presents an internal triangle, even though the lines of such a triangle are not joined. The nose appears unimportant in capturing the attention even of an adult observer. If one covers it, much information is left for the face to be recognized. Hebb (1949) argued that not all the parts of a stimulus are equivalent for its identification; some of them are more characteristic than others, if it is a matter of a single visual fixation, it is of some significance whether it is on one point rather than another.

The existence of poles of visual attraction determined by structural characteristics of the stimulus was confirmed by Kessen and his colleagues (Kessen, Salapatek and Haith, 1965; Salapatek and Kessen, 1967; Salapatek, 1968). The points of visual fixation in neonates were concentrated around the angles of a triangle. Visual exploration following the sides of the triangle from one angle to another, as Hebb had assumed, appeared in a few of the neonates tested. Salapatek (1968) reported that neonates looked at the sides as much as the angles of a triangle. If neonates are capable of fixating the inside of a triangle, they should be able to detect the information about the eyes and the mouth of the mother's face and use it for ~~latter~~ LATER recognition.

The horizontal alignment of the eyes and the mouth could attract the neonates' attention each time the neonate is in face-to-face interaction with the mother and therefore lead to the neonate learning the mother's face. Preference for the horizontal stimuli was proposed by Hebb (1949). He wrote: "the horizontal line...seems of fundamental importance in human perception,..." (p.97). Salapatek and Kessen (1966) found that newborns' eye movements tend to be greater in the horizontal than in the vertical direction. Also, Slater and Sykes (1977) reported that newborns prefer the horizontal stimuli. Future research may need to test these suggestions.

1.2 Developmental changes in processing invariant information.

The present research has made a more extensive attempt to study the processing of invariant information than has previously been done in the literature.

The capacity to recognize the mother's face displaying static expressions suggested that neonates have at least some ability to deal with the commonality amongst a variety of stimulus exposures since the infant has to obtain its central representation of the mother's face from a succession of exposures. However, the results of Experiment 6.1 confirmed the neonates' failure to recognize the 3/4 profile pose of their mother's face and this demonstrated that the perception of invariant information across quite different poses is not possible at this age. Thus, the mother is still only a single pose of the face for the neonate because the 3/4 profile pose is infrequently encountered and neonates have not built a mental schema which includes the different poses of the mother's face. Support for this suggestion comes from the results of Experiment 6.2. One-month-olds were able to recognize the 3/4 profile pose, but not the profile pose. Apparently, the ability to detect invariance develops only gradually. By 1 month of age, infants demonstrate the ability to recognize the slight angular orientation (45^{o}) as the mother's face, but not the 90^{o} orientation. It is not until the third month that such a capacity was detected.

In retrospect, it is unfortunate that Experiments 6.3 did not include the full face pose which would have shown whether preference for the en face pose declines around the third month as it did for the 3/4 profile pose or not. Evidence for a decrease in preference for the en face pose after 14 weeks of age when the faces are silent was reported by Watson et al. (1979) who used the live faces of the mother and that of a male stranger. It is however certain that preference for the en face pose is maintained up to 6 weeks under the present experiment procedures.

The different poses (en face, 3/4 profile and profile) that the infants saw in this research belong to the same category, the mother's face, they share certain features with one another, and differ in other features. To perceive that a pose belongs to a particular category, the infant needs to be able to detect invariance despite those structural aspects which do vary.

These results suggest that around the third month the different poses are perhaps coded in terms of their similarity to a mental schema as Kagan (1971) proposed. Kagan argued that the ability to represent previous objects independent of the current availability of those particular objects and events is an early attainment. The question that arises is whether the representations of the 3/4 profile and profile faces as separate faces exist at all in the mind of the infant before the third month. Kagan agued that a representational capacity is present at 3 to 4 months. However the function of those processes will change in the course of development.

Every day experience with a particular face may provide the infant with information which affects performance in recogition tasks, but it is unlikely that the detection of invariant information is solely a result of active exploration as proposed by the Gibsons (1955, 1969). Such a complex process requires an internal representation to guide it. Support for this argument comes from a study on 15 years old autistic and mentally handicapped (Down Syndrome) children. (Sai, 1984). Though, by the age of 10 the ~~infant~~ CHILD should be able to discriminate facial expressions such as "smile" autistic children failed to discriminate these facial expressions, an ability which requires the processing of invariant information. The Down Syndromes were capable of making such discriminations. As a group the autistics had a better I.Q. than the Down Syndromes, but their perceptual deficiencies (Wing, 1980) prevented them from recognizing even the simplest expressions such as 'laugh'. It is the internal representations of previous perceptual encounters which alters the young infant's distribution of attention. This study on autistic children shows how essential is the presence of abstraction in detecting invariance. To be able to process invariance, the infant must have at least some form of intellectual representation. The impairement of this ability in autistics hindered their discrimination of facial expressions.

In the introduction of Chapter 5, the Gibsons' and Kagan's approaches to the processing of invariance were discussed. We may now return to these issues in the light of the evidence obtained.

J.J Gibson (1979) was concerned with the detection of invariance in a single object. Kagan on the other hand was interested in the ability to refer several similar objects to a common class. Gibson insisted that different processes may operate in these two cases. In the case of the persisting thing, the perceptual system simply extracts the invariant from the flowing array. In the case of distinct things, the perceptual system must abstract the invariants. However Gibson does not admit that the process of abstraction goes beyond the information in the optic array. The findings of Experiments 6.1, 6.2 and 6.3 indicate that some form of intellectual abstraction must be suggested to account for infant detection of invariance and categorization.

The process of abstraction is very complex. One may try to envisage what is involved in this process. Consider the two faces in Figure 6.2.1 (Chapter 6, Exp.1). If these two faces were in the same direction of orientation and were superimposed one on top of the other, there will be a bad superimposition. The features of the two faces are shaped differently. One might argue that recognition of a certain face occurs when there is a perfect superimposition for all of the features as far as the mother's face is concerned. In the case of change in orientation of the face stimulus, attention will be given to those invariant features. In the full face pose, the features are scattered in a given area, the middle. In the profile pose, the scattered features are on one side of the face. This half of the mother's face does not correspond with any particular half of another face even when the two halves have the same hair colour, hair length and colour of the face as in the present research.

Recognition of a face shown in profile, for example, occurs only if the presented face is similar to the prototype constructed of the mother's face. The prototype that the infant derives from a large set is different from the prototype that is derived from a narrower set or a single set. Also, the prototype that the infant builds from the mother's face - a highly familiar stimulus- is different from the prototype that the infant builds from a completely strange face. The familiarity factor leads perhaps to the construction of a prototype of the mother's face at an earlier age. The reinforcement process must play an important role in learning the mother's face. The mother's face is associated with the provision of food, comfort and warmth. It is special to the newborn baby. This suggestion is supported by the finding of the present research indicating processing of invariance at the age of 1 month.

Experience with the mother's face must facilitate the process of abstraction at an earlier age. The breadth of an infant's familiarization experience is related to the breadth of the concept that is constructed. Newborns who had little experience with the mother's face, recognized only the full face and treated a novel orientation of that face (3/4 profile) as a completely novel face. Neonates appeared to have constructed a fairly narrow category, namely "the mother in a particular orientation". Around 1 month, the prototype constructed included the 3/4 profile pose as a result of repeated exposure to the mother's face and development of the infant's representational capacities. At three months, varied experience with the different poses of the mother's face led the infant to pay less attention to a change of orientation. The infants recognized both the 3/4 and profile poses demonstrating that the processing of invariance is guided by mental schema and the presence of intellectual abstraction which Gibson does not admit and Kagan proposed for about 4 months of age.

The suggestion that the processing of invariance does not simply involve the extraction of invariant information as a result of repeated exposure to the stimulus but requires the presence of a mental abstraction is supported by Strauss' (1979) findings. Strauss showed 10 month-old-infants a set of faces that differed along various dimensions such as the length of the nose and the distance between the eyes. The results indicated that a face containing the average of these various values was perceived as familiar and elicited no dishabituation response. This face was considered to be more familiar than a face containing values that had been shown more frequently than the average value.

For Strauss, this averaging ability implies that infants are not simply detecting which values are always present across a set of category exemplars, nor even which values are most frequently present. Instead, infants determine an average value that need not correspond to any presented stimulus, so that a stimulus corresponding to that prototype appears to be more familiar than previously encountered stimuli. Such an averaging process would seem to envolve the type of intellectual abstraction or of "lifting out something that is mental" which Gibson (1979) does not admit.

The results obtained by Strauss thus show that the infant does not simply extract invariant features but under some conditions averages over a set of feature values. The infant comes to perceive a novel stimulus as quite familiar. It is difficult to see how the Gibsons' emphasis on the extraction of invariance from the stimulus array can explain such a finding. Strauss' results support our suggestion that mental abstraction is involved in the detection of invariance.

On the other hand Kagan's attribution of the processing of invariance only to the establishment of mental schema is false. Experience plays a major role in learning the invariants of any object. Also, Kagan's view that the role of schema changes as a result of maturation seems weak. Experience also has an important role for changes in memory processes. The elaboration of particular schemata will depend on specific encounters with the world. Encounters that are somewhat, but not totally different from, existing schemata have the most formative role in revision of those existing schemata. Kagan has not been precise about how exactly such revisions occur. Does the infant create a new schema which averages across the old schema and the newly experienced stimulus? Does this new stimulus strengthen those aspects of the schema with which it does correspond while attenuating those aspects from which it deviates? Kagan does not clarify these points but the experimental work on object identity is gradually being guided by these kinds of questions.

A second problem that arises for the Gibsons' theory concerns the specification of the relationship between the detection of invariance and the differentiation of distinctive features. The detection of invariance involves the search for similarities across a class of stimuli. The differentiation process, however, requires the perceiver to concentrate on those features that vary within the class. The differentiation process involves: a) Attending to dimensions of variation and b) ignoring dimensions that show little variation. The results of Experiments 6.2 and 6.3 indicate in both 3/4 and profile poses that there were invariant and variant features. To be able to discriminate between the mother and stranger's faces, infants must have recognized some invariant features and ignored the 45 degree change of orientation. This is what happened for 1 month-olds. If the search for variance involves just the attention to dimensions that exhibit little variation, the 1 month-olds would have recognized the profile pose of the mother's face, as some features such as the contour, the shape of nose, brightness of the face remained invariant. The search for similarities involves the process of differentiation. According to the Gibsons, the search for invariance requires the adoption of the following rule: a) attend to dimensions that exhibit little variation and b) ignore dimensions of variation.

It can be argued that the concentration on relative invariance leads the infant to do the opposite of what is called for by the Gibsons' process of differentiation. The first calls for the storage of features that do not vary, whereas the second involves selective attention to those that do. The problem for the Gibsons' theory is it does not provide any clear account of when one process operates and not the other, it can only account for any given result by calling on either process in an ad hoc fashion. These two processes are guided by mental capacities. One might envisage how these two processes might coexist? We may propose a storage system concerning the mother's face.

When encountering any face, the infant retrieves that prototype to which it bears the most resemblance. A rapid comparison process ensures whether the presented face is similar to the prototype or not. The features showing degrees of invariance are stored. In a recognition task, the infant ignores all features showing correspondence with the prototype. Attention is captured by those features that do not correspond to the prototype. These features captured 1 month olds leading to their failure to recognise the mother. These noncorresponding features can be divided into two different types. First, features that the prototype does not include. Second, features that vary across members of the category and are not stressed in the prototype. Both of these kind of features will distinguish between instances of a category, while the features that the prototype include will not.

In the course of time, the stored representation of the mother's face is modified. The prototype of the full face, constructed soon after birth, includes more and more details about the features. Following experience with the mother's face, the infant encodes and stores minor and larger details. Repetition of given values leads to a reactivation or strengthening of those features that already exist. Facial details are retained but will undergo forgetting if they are not reactivated. This suggestion is supported by the findings of Rovee-Collier et al., (1981). Three month-old infants learned to move a crib mobile which was attached to their ankle by a ribbon. In the absence of training forgetting occurred after 8 days. A brief exposure to the mobile (even when the ribbon was absent), 24 hours before the retention test was given, eliminated forgetting. Reactivation is effective even if it occurs 24 hours before a retention test given 2 or 4 weeks after the original learning, when forgetting would normally have entirely occurred. For Rovee-Collier et al., stimulus repetition is sufficient to ensure retrieval of information that would otherwise be inaccessible.

The mother's face, a highly familiar stimulus which the infant encounters, is learned rapidly as a result of this strengthening process. Reactivation occurs only if the face the infant sees is highly similar to the original stimulus or face. A face showing a major departure from the prototype will not reactivate this prototype and vice versa.

In conclusion, it can be said that as Harris (1983) suggested, memory for a given stimulus will, with time, reflect those features of the stimulus that it shares with other stimuli. Aspects of the profile pose of the mother's face that are not shared with the full face pose, for example, will not be experienced with great frequency and in the absence of reactivation forgetting will occur as happened for the 1 month-olds who could not remember the profile pose of their mother's face.

In other words, with repeated exposure to a given face or orientation, the prototype constructed will be stored in long-term memory. The short-term storage is both prototypical and idiosyncratic according to the above suggestions. Any face shown in any orientation is referred to and compared with the prototype that it resembles. Each feature which does or does not correspond with the prototype is encoded so that the process of comparison can take place.

The above assumption allow us to explain how the infant of 1 to 3 months can attend to dimensions of variation while also emphasizing invariance in the mother's face. The presence of a prototype of the mother's face (or any other face) allows the infant to discriminate between members of a category (such as between the faces of two females having the same hair colour and facial brightness and also among the different orientations of the mother's face which constitute a category) by paying attention to features showing little or no correspondence with the prototype. In the course of time the representation of the mother's face shows a concentration on relative invariance like the prototype. The absence of strengthening deletes variable features from memory.

The theory that one may suggest for the processing of invariance is the combination of experience with a certain stimulus and a mental representation of that stimulus, though experience is very important because it is at the origin of the establishment of the prototype. The presence of intellectual abstraction is necessary too. Without a mental abstraction of the stimulus, and the presence of storage systems, the information detected is lost. It is like pouring water into a broken glass. In other words the processing of invariance involves a combination of the Gibsons' and Kagan's theories while admitting the role of memory in the processing of invariant information.

1.3 Implications of the present findings for theories of perception.

Not so long ago, it was widely believed that newborn infants are blind and for a number of weeks deaf. The evidence now available indicates that at birth the neonate does see and hear. A number of conclusions that characterize perception in young infants are now justified. The propositions in the following paragraghs have been supported by empirical evidence.

Perception is active, exploratory in the newborn baby. Neonates are not passive. They actively obtain information. Visual information is certainly picked up and processed by 12 hours after birth. Even when auditory and olfactory information are controlled recognition of the mother's face occurred in infants tested in this thesis. Neonates selected the mother's face even when the mother's and stranger's faces were matched in terms of hair colour and facial colour. As the Gibsons pointed out, the process of perceiving is selective from the start. Infants detect a moving high contrast stimulus from birth and can move their eyes toward a stationary stimulus in the immediately accessible optic array, particularly if it shows high contrast with its context and or it is in motion (Banks & Salapatek, 1983).

Evidence suggests that acuity for static presentations is poor, but attention is given to some properties of the optic array. The newborn baby demonstrated a preference for the mother displaying a still neutral expressions. Neonates recognized their mother even when paired with a comparable face of a female stranger, and a control for observer bias was implemented. To make such discrimination the neonate must have searched actively to obtain the appropriate information from the stimuli (faces). Sometimes, however, the information is too abstract for the neonates to process. Neonates were unable to recognize the 3/4 profile pose of the mother and 1 month-olds failed to discriminate the profile pose of the mother. These two presentations of the mother's face contained abstract information.

In formulating a theory of perceptual learning, E. Gibson (1969) proposed that reduction of information served as a kind of reinforcement in perceptual learning. Recently, Gibson (1987) phrased the idea differently. Active perception is a search for order and invariants. Do the findings of the present thesis favor this idea? Neonates who successfully visually recognized the mother's full face were unable to discriminate the 3/4 profile pose of the mother's face. Similarly, 1 month-olds who recognized the 3/4 profile failed to show recognition for the profile pose of the mother's face. In all these cases neonates searched for order and invariants to be able to discriminate between the mother's and stranger faces but the slight deviation (45^{o}) affected neonates and a 90^{o} orientation prevented 1 month olds recognizing their mother's face. In both 3/4 and profile poses there were still some invariant features. The change in orientation prevented infants detecting such invariants. These results suggest that search for invariants must be guided by a mental representation. How can one recognize that a ~~such~~ feature is invariant if it had not been seen before and remembered. To be able to remember a face or an object, one must have an abstract representation of that face or that object. The Gibsons' theory is weak in that it does not admit that intellectual abstraction must account for infant extraction of invariance and categorization.

Attention is guided by constructed prototypes. Perceptual categorization is present at 3 months in young babies and even at 1 month of age when information is not too abstract. The 1 month-olds demonstrated recognition of a familiar face (3/4 profile pose of the mother's face) that had not been seen frequently but which corresponded to a mental prototype. An ability to use a prototype appears to demand a capacity more akin to recall than to recognition. The 3/4 profile pose for newborns and the profile pose for 1 month-olds are perhaps seen infrequently- and even when they are experienced, the poses tend not to be maintained consistently at the same angle. A previously seen face that cannot be truly recognized is seen as less familiar as long as it does not correspond to the stored prototype. Hence, the distribution of attention is governed less by recognition than by the recall of some schema abstracted from those stimuli.

However representation which Kagan proposed appeared at 4 months of age must be present even earlier, at around 1 month. Also it may be that the capacity for representation does not emerge in a unified fashion at any single point in development. The ability of the newborns to discriminate the full face, but not the 3/4 profile, and 1 month -olds' capacity to recognize 3/4 profile but not the profile pose of the mother's face and the recognition of the mother's profile pose at 3 months of age indicate that different types of representation emerge stage by stage. The construction of prototypes is not a single process but varies with the nature of the materials. The prototype of the mother's face is surely established before other prototypes.

A question that arises is: Is perceptual learning one of the factors underlying developmental changes in perception? Most psychologists would grant that it is, but there is another issue. There are perceptual theorists who argue that what is externally available to perception is impoverished, comes piecemeal and must be supplemented by something else to yield meaningful perception. This supplementation was explained as the association of one perception with another or with ideas or responses or as inference from traces of previous experience or from inborn premises. In contrast, some theories assume that information is there, in a spatially and temporally extended array, specifying the events, surfaces, and objects in the world. E. Gibson argues that the infant must learn to extract this information from the available stimulation to discover the invariants and regularities that specify permanent aspects of the environment and detect the changes. The infant eagerly searchs for information about the world. For Gibson the evidence suggests that structure (optical structure in the case of vision) is being discriminated very early by the young infant and is differentiated more finely with time. The findings of Experiments 6.1, 6.2, 6.3 support this view. It is not until the third month that the profile pose was recognized. Recognition of the mother's face develops by stage. If very young infants extract all the information characterizing the mother's face, they would be then able to recognize different poses. Since young infants extract information piecemeal and such a process of extraction is guided by constructed prototypes, the mother's face is differentiated more finely only by the third month.

An alternative view to Gibson's approach is one which sees habituation as a kind of passive perceptual learning, a sort of stamping of a trace to make a copy or representation (Sokolov, 1963). It should be pointed out that even in habituation, the infant must search for information. It is the infant who selects information and extracts it. Active exploration is involved in even the earliest perceptual learning. The idea of a passive perceptual learning is inadequate.

A related issue is that of whether the perception of infants is meaningful. Meaning as a concept has always been loaded with traps, but as one reviews the research on newborn babies, it is difficult to justify the position that what they perceive is completely without meaning. Neonates engage in a kind of dialogue with a caretaker (Trevarthen, 1977) or discriminate intonation in a voice and use it to recognize their mothers (Mehler et al., 1978). Examples also include the discrimination of the mother's face from another female similar in hair colour, facial brightness and hair length. If neonates do not attach a meaning to the mother's face they may differentiate it from others, but why show a consistent preference? The meaning which the neonate attaches to the mother's face is perhaps the satisfaction of the baby's need. The neonate detects the utility of the face perceived. This is how meaning begins and grows with reinforcement. The mother's face means food and other positive aspects. Learning the mother's face involves the presence of memory and of at least some understanding on the part of the neonate.

1.4 Evidence for preference for familiarity

The findings of this research indicate a familiarity preference. The mother's face was preferred to the face of a female stranger both in the neonatal period and at 1 and 3 months of age. This is perhaps due to the use of a spontaneous visual preference and short trials (2), each of 20 secs. Since the infant were often not with their mothers prior to testing and therefore were not familarized prior to testing, and the testing did not last long, there was little opportunity for the infant's attentional preference for the mother to decrease. Evidence from habituation suggests that a preference for the novel stimulus generally follows after continuous exposure to the familiar stimulus (Barrera & Maurer, 1981 and Field et al., 1984). However, there is a considerable difference between a short-term habituation study and long term naturalistic exposure to a stimulus which is being associated with pleasurable experience and if we adopt a conditioning model, it is more reasonable to expect a preference for the familiar face than a preference for a novel face.

The familiarity preference reported in the neonatal period is however not in accord with Hebb's (1946) Berlyne's (1960) and Hunt's (1965) views. They suggested that the mother is less attention-worthy than a stranger in a novel situation because she is a familiar object in an unfamiliar context. The organism, in the face of the very familiar mother stimulus, may experience a high degree of novelty deriving from incongruity, or violation of expectation. The mother stimulus induces expectations on the basis of experience which are not found under typical experimental conditions. Normally, the input from the mother's face is accompanied by her voice, smell, etc. If the mother's face, frequently associated with changes of input from the environment, appears through a window surrounded by a white sheet as in the present experiment, the infant's expectation must be violated according to Hebb's, Berlyne and Hunt assumptions. The violation-of-expectation or stimulus incongruity hypothesis is contradicted by the findings of the present research demonstrating a familiarity preference even when infants were tested in a completely novel environment, and when auditory and olfactory information were absent. According to the violation-of-expectation hypothesis, when there is too much incongruity or violation of expectation, the organism returns to a lower level of arousal by escaping the situation. However, since neonates cannot physically escape, they achieve the same effect by closing their eyes. In the present research, neonates did not show such behaviour.

1.5 Memory capacity

The data from this research provide evidence for the presence of visual memory in the neonatal period. The ability to recognize the mother's face from that of a female stranger even when the two faces were matched for hair colour, hair length and facial brightness suggests that the neonate stores and remembers specific details about the mother's face. A stimulus is familiar because it is remembered (e.g. Sokolov, 1963;' Lewis, 1967).

The fact that neonates were neither habituated to the mother's face during testing, nor were they in face-to-face interaction with the mother suggests that infants are capable of lengthier retention than was previously thought even within the first days of life. The presence of long-term memory capacity in young infants was reported by Little, (1970, 1973) and Papousek (1970) and by Bushnell, McCutcheon, Sinclair and Tweedlie (1984) but only with older infants. In the latter study, 2 week-old infants were familiarized to a geometric stimulus for 30 minutes per day over a two-week period. Around the 4th week, after delayed recognition testing, a significant novelty preference was demonstrated. In the present research, neonates could have stored some visual aspects of their mother's face in the first few hours after birth. The mother's face may have been associated with positive reinforcing experiences (e.g. food, warmth). The perception of the mother's face requires the integration of sensory information from the different modalities and at least some developed storage and retrieval mechanism with which to make comparisons. It follows that the infant's ability to recognize the mother suggests the neonate's capacity to retain information over lengthy time periods and is not a short-term habituation effect. The direction of preference itself, negates the possibility of habituation as an explanatory variable.

Research designed to explore what the newborn baby attends to in the mother's face, or more specifically, what attributes of the presented features are selected for storage in the infant's memory and how the abstraction and storage of aspects will influence subsequent recognition behaviour is needed.

The finding that 1 month- and 3 month-old infants recognized only some poses of the mother's face demonstrates that they responded to the poses they remembered most.

1.6 The relationship between amount of contact with the mother and extent of preference.

The relationship between the total number of contact hours involved between the mother and the newborn baby and the extent of preference for the mother is still not certain. The results of the observational study (Experiment 7.1) indicate that on average neonates spend on their first day 21% of their awake time in face-to-face interaction with the mother. This amount increased in the second day (22.5%) and on the third day (37.4%), but the difference between days 1 and 2 was not significant. It is however, clear that the mothers established frequently face-to-face contacts since the first few hours after birth. Experience with the mother's face obviously helped neonates learn to recognize that face. This process may have been assisted by the mothers vocalizing to their infant in most interactions they had. The voice cue may provide important information that could direct infants' attention to the mother's face and provide important associational cues.

Due to practical difficulties, it was not possible to test the observed group, but since this study observed the same age group from the same wards as experiments reporting early face recognition, the data of experiment 7.1 could be related to the visual behaviour of neonates in Experiment 2.1. Both the amount of face-to-face interaction and the relationship between age and extent of preference for the mother did not significantly increase over the first days of life. Younger babies (1 day-olds) were as good as older ones (3 day-olds) at recognizing their mother not only in Experiment 2.1 but in all experiments of Chapter 4 testing early face recognition. Therefore, preference for the mother's face is not related to the amount of contacts between the mother and her newborn baby, at least once a certain level of exposure has been attained. It follows that learning the mother's face is rapid though it may be a cumulative process.

That the neonate was not continually exposed to the mother's face suggests very rapid learning. The presence of a preference for the mother in babies aged 12 hours of age (Exp. 2.1) reveals an amazing ability on the part of the newborn baby. Perhaps neonates remember the mother's face because it is the first face which is associated with the provision of food and comfort.

It should be noted, however, that there were clear individual differences in the amount of contacts that each mother/stranger pair had in the observational study (Chapter 7). Some babies spent most of their time sleeping, others were either awake or with the mother (see Figure 7.1.1, Chp. 7). These babies had more contact with the mothers whether the latter liked it or not. Thus, the state of the infant is an important determinant of the amount of contact the mother and neonate have from birth. Mothers who smoked had less contacts with their babies than non-smoker mothers, as they were more frequently absent from the ward (quantitative data on this point is not available). Subsequent research would beneficially test infants whose individual exposure to their mother had been assessed.

The use of video to record the contacts between the mother and infant is necessary to provide greater detail of interactions especially the visual contact aspects. Time sampling procedures must inevitably provide less information than continuous recording of the contacts on video. Thus the latter would give more information about such a complex relationship.

1.7 Sex differences

The data of this research add further confusion and contradiction to the literature on sex differences. Contrary to Field et al.'s (1984) study which reported a slight superiority on the part of female infants, Experiment 2.1 found a sex effect, with male neonates demonstrating stronger preferences for the mother's face than did females.

In Experiments (4.1 and 4.2), where the olfactory mask was implemented, the sex effect was not significant. The analysis of the combined data indicated a tendency towards a greater preference for the mother on the part of male infants, though the difference did not reach significance.

In conclusion, one needs to stress that sex effects are not consisant from one study to another, in the developmental literature and they are not reliable in this set of experiments.

Conclusions

The present data indicate that face recognition is possible, in a sample of infants aged 12 hours, at least when tested under the present experimental procedures. Preference for the mother's face was found even when auditory and olfactory information were unavailable, and the comparison faces were matched as closely as possible for hair colour, hair length and facial brightness.

However, recognition of the mother's face in the neonatal period seems to be confined to the en face pose. The identity of the mother was not conserved through orientation change. An increase in angular deviation (45^{o}) led to a failure of recognition. The neonates' failure to discriminate their mother's face viewed in another pose (3/4 profile pose) has been attributed to their inability to detect invariance. The capacity to process invariant information seems to develop partly by the first month and continues to mature around the third month until it reaches a substantial developmental level sometimes around the third month.

By 1 month of age, infants seem to have learned the 3/4 profile pose of the mother and combine both this pose and the en face into a single "perceptual category", the mother's face. Later, around the third month, infants have developed a broader internal representation of the mother's face which includes the profile pose. Better developed storage and retrieval mechanism with which to make comparisons are inferred at this age.

Though, the present research confirmed Field et al.'s (1984) finding that face recognition is possible in the neonatal period and ruled out the hypothesis that young infants might be using their mother's odours or voice in the discrimination process, it did not determine which visual information is being processed and utilised.

The data from this research suggest rapid learning on the part of newborn babies. The amount of contact between mother and neonate indicates that the neonates are not continually in face-to-face interaction with their mothers in the first three days after birth, and must be processing visual information from the mother's face in the first hours after birth.

This research has helped in the understanding of how newborn babies process information about faces, ALTHOUGH ~~altough~~ many questions remain to be answered about the processing of visual information by a system which was previously believed to be severely limited in the neonatal period.

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APPENDIXES

the Chapter.

The subjects' numbering in Appendixes does not correspond with the numbering in the tables in the text.

APPENDIX 2.1

2.1.1

The Apgar score (Apgar, 1953) is a rating by a pediatrician made within 1 minute and 5 minutes after birth on the respiratory efficiency, heart rate, reflex irritability, muscles tone, and body colour of the infant. The score on each of these varies from 0 to 2 with a maximum score for all five ratings of 10. A high score indicates a more favorable condition. A total of 7 to 10 demonstrates that the neonate is in good condition. A score below 5 shows that there may be possible developmental difficulties, and a score of 3 or lower indicates that there may be a problem in survival. Only babies who scored 5 and more were used in this study. The actual Apgar scores were available at the end of each testing.

Subject's number: Code:

Position of mother on first trial:

Date of testing: Time:

Subject's name: Sex:

Date and time of Birth: Age:

Birth Weight: Mother's hair colour:

Birth order: Mother's complexion colour:

Is she wearing glasses ?
Is she Breast or Bottle Feeding?

~~Term gestational age:~~

Is the Stranger Breast or Bottle feeding?

~~Ponderal index:~~

Is she a smoker ?
Stranger's hair colour and length:
Complexion colour:
Is she a smoker ?

Delivery: SVD MCFD LUSCS

Apgar: at 1mn. at 5mins. at 10mins.

Maternal Medication:

Type: Amount: Time given:

Holder: Observer: Stranger:

Participants' Opinions: To which direction the baby was looking to ?

	First trial:			Second trial:		
	M	=	S	M	=	S
Mother:						
Stranger:						
Observer:						

Comment on test procedure:

Appendix 3.1

A threshold is "...the minimum concentration of a stimulus required to elicit a response, or the degree of just detectable difference between two parallel stimuli. In either case, the threshold is a statistical calculation of a psychophysical response" (Pangborn, Berg, Roessler and Webb, 1964, p.91).

APPENDIX 4

Appendix 4.4.1 Response Sheet

Subject's Name:

Age:

Sex:

Decide on which side the mother is circle as appropriate. Please indicate how you came to your decision. Wait until each pair are finished before you make your decision.

1- L R Why?
2- L R Why?
3- L R Why?
4- L R Why?
5- L R Why?
6- L R Why?
7- L R Why?
8- L R Why?
9- L R Why?
10- L R Why?
11- L R Why?
12- L R Why?
13- L R Why?
14- L R Why?
15- L R Why?
16- L R Why?
17- L R Why?
18- L R Why?
19- L R Why?

Appendix 6.2.1. Letter to parents

UNIVERSITY OF GLASGOW

DEPARTMENT OF PSYCHOLOGY

ADAM SMITH BUILDING

GLASGOW, G12 8RT
Tel. 041-339 8855

Dear Mrs

During your stay at ROTTENROW, you very kindly provided us with some information about your baby. Now we would like to have the opportunity to see your baby. Our interest is in the way that babies look at faces and whether theycan tell the difference between different faces.

This would involve a very brief visit to us (at our developmental unit located in 62 Hillhead Street) during which we will simply look at your baby as he/she is looking at one or two faces.

We suggest, as a suitable date, 1986, at , but if this is not possible, please suggest another date and time, either by dropping us a line in the enclosed stamped, addressed envelope or by telephoning 339 8855, ext 5526 or 5142.

We will of course arrange to have you collected and returned by Taxi at our expense.

Yours sincerely

APPENDIX 7

Recording Format 7.1.1

Frequency of occurrence (A)

Subject's name: sex:

Date and Time of Birth:

Location:

RECORDING BY TALLY MARKS.

Date Time

Day No. Session No. Subsession No.

1- Caretaking behaviours

	1- Physical (PHY)						2- Verbal (V)			3-Tend	
	Feeding			Changing			Spk	Mvn	Sing	Wip	Wind
	F1	F2	F3	Ch1	Ch2	Ch3					
1st 5mn											
2nd 5mn											
3rd 5mn											
4th 5mn											
5th 5mn											
6th 5mn											
7th 5mn											
8th 5mn											
9th 5mn											
10th5mn											
11th5mn											
12th5mn											

Recording Format 7.1.1

Frequency of occurrence (B)

Subject's name: sex:
Date and Time of Birth:
Location:

RECORDING BY TALLY MARKS.

Date Time

Day No. Session No. Subsession No.

2- Affectionate behaviours

	1- Expressive					2-Physical					
	Smil	Laug	Gig	Smi/So		Kis	Hug	Cud			
1st 5mn											
2nd 5mn											
3rd 5mn											
4th 5mn											
5th 5mn											
6th 5mn											
7th 5mn											
8th 5mn											
9th 5mn											
10th5mn											
11th5mn											
12th5mn											

Appendix 7.1.1

Recording Format 7.1.1

Frequency of occurrence (C)

Subject's name: sex:
Date and Time of Birth:
Location:

RECORDING BY TALLY MARKS.

Date Time

Day No. Session No. Subsession No.

3- Visual behaviours

	1- Mother					Infant				
	Df1	Sn	Pv	Low	Cey	Df	Sn	Pv	Low	Cey
1st 5mn										
2nd 5mn										
3rd 5mn										
4th 5mn										
5th 5mn										
6th 5mn										
7th 5mn										
8th 5mn										
9th 5mn										
10th5mn										
11th5mn										
12th5mn										

Recording Format 7.1.1

Frequency of occurrence (D)

Subject's name: sex:

Date and Time of Birth:

Location:

RECORDING BY TALLY MARKS.

Date Time

Day No. Session No. Subsession No.

4- Play behaviours

	1- Stimulating					2- Physical					
				St	Aha	Tic	Nib	Rou	Tum		
1st 5mn											
2nd 5mn											
3rd 5mn											
4th 5mn											
5th 5mn											
6th 5mn											
7th 5mn											
8th 5mn											
9th 5mn											
10th5mn											
11th5mn											
12th5mn											

Appendix 7.1.1

Recording Format 7.1.1

Frequency of occurrence (E)

Subject's name: sex:

Date and Time of Birth:

Location:

RECORDING BY TALLY MARKS.

Date Time

Day No. Session No. Subsession No.

5- Approaching the infant

	1- Way					2- Side					
			Ge In	War Im	Har	Rig	Lef	Fee	Hea	Sid e	
1st 5mn											
2nd 5mn											
3rd 5mn											
4th 5mn											
5th 5mn											
6th 5mn											
7th 5mn											
8th 5mn											
9th 5mn											
10th5mn											
11th5mn											
12th5mn											

Appendix 7.1.1

Recording Format 7.1.1

Frequency of occurrence (F)

Subject's name: sex:
Date and Time of Birth:
Location:

RECORDING BY TALLY MARKS.

Date Time

Day No. Session No. Subsession No.

6- Soothing behaviours

	1- Physical					2- Verbal					
			Wi In	Pic		So/ M	Wor	Sou			
1st 5mn											
2nd 5mn											
3rd 5mn											
4th 5mn											
5th 5mn											
6th 5mn											
7th 5mn											
8th 5mn											
9th 5mn											
10th5mn											
11th5mn											
12th5mn											

Appendix 7.1.1

Recording Format 7.1.1

Frequency of occurrence (G)

Subject's name: sex:
Date and Time of Birth:
Location:

RECORDING BY TALLY MARKS.

Date Time

Day No. Session No. Subsession No.

7- Respondent behaviours

	1- Physiacl					2- Verbal					
			Pic	Cud	Fing	Wor	Von				
1st 5mn											
2nd 5mn											
3rd 5mn											
4th 5mn											
5th 5mn											
6th 5mn											
7th 5mn											
8th 5mn											
9th 5mn											
10th5mn											
11th5mn											
12th5mn											

Appendix 7.1.1

Recording Format 7.1.1

Frequency of occurrence (H)

Subject's name: sex:

Date and Time of Birth:

Location:

RECORDING BY TALLY MARKS.

Date Time

Day No. Session No. Subsession No.

8- Other behaviours

1st 5mn											
2nd 5mn											
3rd 5mn											
4th 5mn											
5th 5mn											
6th 5mn											
7th 5mn											
8th 5mn											
9th 5mn											
10th5mn											
11th5mn											
12th5mn											

Appendix 7.1.1

Recording Format 7.1.2

Nature and duration of each of the behaviours (A)

Subject's name: sex:

Date and Time of Birth:

Location:

RECORDING: the number of seconds that each mother/infant are engaged in each behaviour.

Date Time

Day No. Session No. Subsession No.

1- Caretaking behaviours

	1- Physical (PHY)						2- Verbal (V)			3-Tend		
	Feeding			Changing								
Subj.	F1	F2	F3	Ch1	Ch2	Ch3	Spk	Mvn	Sing	Wip	Wind	
1												
2												
3												
4												
5												
6												

This is a sample of Record format 7.1.2

Appendix 7.1.1

Record Format 7.1.3

States of:

```
          Infant               I             Mother
                               I
Awak Slep W/Vis W/N W/Mot      I Awak Slep W/Vis Ch Abs Rea
                               I
                               I                           I
```

Awak: Awake alone
Slep: Sleeping
W/Vis: With visitors
W/N : With nurse
W/Mot: With Mother
Ch : Mother chatting
Abs : Mother absent from the ward
Rea : Mother reading

Appendix 7.1.2

Questionnaire

Feeding

Q- Did you feed your baby last night?

A- Yes No

Q- If yes, how many times?

A- Breast.........Bottle......

Changing

Q- Did you change your baby last night?

A- Yes No

Q- If yes, how many times?

A- ....

Appendix 7.2 Raw data (frequency of behaviours during 5 mins recorded by observer1 (author) and observer2 (a naive observer)) of an additional group of 6 pairs mother-infant used to calculate the reliability of the recordings of observer1

The sub-behaviours are referred to by their initials (see method section of Chapter 7 for explanations of these initials).

ob1: author
ob2: a naive observer

r: Spearman Correlations
Ss: Subjects

1- Caretaking behaviours

Feeding

	F1		F2		F3	
Ss	ob1	ob2	ob1	Ob2	ob1	Ob2
1	1	1	1	1	1	1
2	0	0	0	0	0	0
3	2	2	2	2	2	2
4	1	1	1	1	1	1
5	0	0	0	0	0	0
6	1	1	1	1	1	1
r= 1			r=1		r=1	

Changing

	CH1		CH2		CH3	
Ss	ob1	Ob2	ob1	ob2	ob1	ob2
1	1	1	1	1	1	1
2	0	0	0	0	0	0
3	1	1	1	1	1	1
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	1	1	1	1	1	1
r=1			r=1		r=1	

Tend

	Wip		Wind	
Ss	ob1	ob2	ob1	ob2
1	1	1	1	1
2	1	2	2	1
3	0	0	0	0
4	2	2	2	3
5	0	0	0	0
6	1	2	0	0
r=0.94			r=0.94	

Verbal

	SPK		MVN		SING	
Ss	ob1	ob2	ob1	ob2	ob1	ob2
1	1	2	1	2	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	3	4	3	5	0	0
5	0	0	0	0	0	0
6	1	2	2	4	0	0
r=0.91			r=0.88		r=1	

2- Affectionate behaviours

Expressive

	SMIL		LAUG		GIG		SMI/SO	
Ss	ob1	ob2	ob1	ob2	ob1	ob2	ob1	ob2
1	2	1	0	1	0	0	1	1
2	0	0	0	0	0	0	0	0
3	1	2	0	0	0	0	0	0
4	2	1	0	0	1	2	1	2
5	0	0	0	0	0	0	0	0
6	3	4	0	0	2	1	3	1
$r=0.88$			$r=0.97$		$r=0.94$		$r=0.85$	

Physical

	KISS		HUG		CUD	
Ss	ob1	ob2	ob1	ob2	ob1	ob2
1	2	3	1	1	2	3
2	0	0	0	0	0	0
3	0	0	0	0	1	1
4	3	1	0	0	3	1
5	0	0	0	0	0	0
6	2	1	0	0	4	2
$r=0.82$			$r=1$		$r=0.74$	

3- Visual behaviours

Mother

Ss	DF ob1	DF ob2	SN ob1	SN ob2	PV ob1	PV ob2	LOW ob1	LOW ob2	CEY ob1	CEY ob2
1	3	1	2	0	1	2	0	0	0	2
2	0	0	0	0	0	0	0	0	0	0
3	4	2	2	1	2	1	0	0	1	0
4	1	3	1	3	1	0	1	1	2	0
5	0	0	0	0	0	0	0	0	0	0
6	1	3	3	1	1	0	1	2	1	3
	r=0.54		r=0.65		r=0.88		r=0.97		r=0.65	

Infant

Ss	DF ob1	DF ob2	SN ob1	SN ob2	PV ob1	PV ob2	LOW ob1	LOW ob2	CEY ob1	CEY ob2
1	1	0	2	1	1	0	0	1	2	3
2	0	0	0	0	0	0	0	0	0	0
3	2	1	1	2	2	4	0	1	2	1
4	0	0	1	2	3	1	1	1	2	2
5	0	0	0	0	0	0	0	0	0	0
6	1	3	1	2	0	1	0	0	2	4
	r=0.82		r=0.88		r=0.71		r=0.94		r=0.88	

4- Play

STimulating

Ss	ST ob1	ST ob2	AHA ob1	AHA ob2
1	1	1	0	0
2	0	0	0	0
3	0	2	0	2
4	0	0	0	2
5	0	0	0	0
6	0	0	0	0
	r=0.91		r=0.88	

Physical

Ss	TIC ob1	TIC ob2	NIB ob1	NIB ob2	ROU ob1	ROU ob2	TUM ob1	TUM ob2
1	0	0	1	3	1	0	0	0
2	0	0	0	0	0	0	0	0
3	1	3	0	2	0	0	0	0
4	2	1	1	1	0	0	0	0
5	0	0	0	0	0	0	0	0
6	2	4	2	3	0	0	2	0
	r=074		r=0.74		r=0.97		r=0.88	

5- Approaching the infant

Maner

Ss	GEN ob1	GEN ob2	WAR ob1	WAR ob2	HAR ob1	HAR ob2
1	1	1	1	1	0	0
2	0	0	0	0	0	0
3	0	2	2	1	0	0
4	1	1	3	1	0	0
5	0	0	0	0	0	0
6	2	0	4	2	0	0

r=0.88 r=0.71 r=1

Direction

SS	RIG ob1	RIG ob2	LEF ob1	LEF ob2	FEE ob1	FEE ob2	HEA ob1	HEA ob2	SIDE ob1	SIDE ob2
1	3	4	1	2	1	1	1	0	1	1
2	1	1	1	1	1	1	0	0	0	0
3	2	1	3	1	2	1	2	1	0	0
4	2	0	4	2	0	0	1	1	0	1
5	3	1	1	1	0	0	0	0	0	0
6	2	0	2	0	2	0	0	0	0	0

r=0.6 r=0.6 r=0.85 r=0.94 r=0.97

6- Soothing

	a) Physical				b) Verbal					
	WIN		PIC		SO/M		WOR		SOU	
Ss	ob1	ob2	ob1	ob2	ob1	ob2	ob1	ob2	ob1	ob2
1	1	1	1	1	0	0	2	1	0	0
2	0	0	0	0	0	0	0	0	0	0
3	2	0	1	1	1	1	1	1	1	1
4	1	3	1	2	2	1	1	0	2	2
5	0	0	0	0	0	0	0	0	0	0
6	0	3	0	0	0	0	1	0	0	0
	r=0.49		r=0.97		r=0.97		r=0.91		r=1	

7- Respondent

	a) Physical				b) Verbal					
	PIC		CUD		FING		WOR		VON	
Ss	ob1	ob2	ob1	ob2	ob1	ob2	ob1	ob2	ob1	ob2
1	1	1	0	0	4	1	1	0	1	1
2	0	0	0	0	0	0	0	0	0	0
3	2	1	1	2	1	2	2	0	2	2
4	1	3	1	1	0	1	1	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	2	2	0	0	1	2	0	2	3	1
	r=0.85		r=0.97		r=0.65		r=0.71		r=0.88	

8- Other

Ss	ob1	ob2
1	1	2
2	0	0
3	2	0
4	2	1
5	2	0
6	0	0
	r=0.71	

* Interobserver reliability: r=0.85, p<0.05, one-tailed.